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METEOROLOGICAL STUDY FOR TOOELE ARMY DEPOT. VOLUME I

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A meteorological study concerned with the assurance of air quality during planned demilitarization operations at Tooele Army Depot, South Area (TEAD-S), was conducted by Dugway Proving Ground under the sponsorship of the Program Manager for the Demilitarization of Chemical Materiel.

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The purpose of this study was to investigate the diffusion aspects of air contaminant emissions from demilitarization operations at the proposed location as they are related to both State and Federal air quality standards and to additional standards as imposed by the Army for this operation.

Continuous 1-hour plant stack emissions were stimulated utilizing a fluorescent particle tracer. Simulated emissions were made over a wide variety of atmospheric conditions. The behavior of this material has been studied and analyzed.

The cost of a sampling network designed to detect maximum short-term ground-level concentrations (1 to 8 hours) at the periphery would be prohibitive. Thus, a reliable safe-sided model to predict ground-level concentrations at the periphery of TEAD-S was developed. This model, when utilized in conjunction with the eight-station air monitoring network, will provide more complete assurance that air quality standards have not been exceeded. It is recommended that the meteorological tower, which was installed for this study, be maintained and operated during demilitarization operations.

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FOREWORD

U. S. Army Dugway Proving Ground, Dugway, Utah, was responsible for the coordination of this study effort.

The work was sponsored and funded by the office of the Program Manager for the Demilitarization of Chemical Materiel, Edgewood Arsenal, Aberdeen Proving Ground, Maryland. Staff assistance throughout the program was provided by Mr. D. L. Pugh and LTC R. L. Hanson of the Program Manager's office. Significant contributions throughout the program were also provided by LTC P. J. Madden and LTC R. J. Murphy of the US Army Environmental Hygiene Agency, Aberdeen Proving Ground, Maryland. The diffusion models utilized in the design of the field experiment were developed by Dr. Harrison E. Cramer of the H. E. Cramer Company, Inc. Considerable assistance in the analysis phase of this program was provided by Mr. Jim Bowers and Dr. Harrison E. Cramer of the H. E. Cramer Company, Inc.

Because of the bulk of test data contained in this report, the report has been divided into two volumes: Volume I contains Section 1, Summary; Section 2, Details of Study; and Section 3, Appendices. Volume II contains Section 3, Appendices (Continued).

TABLE OF CONTENTS

VOLUME I

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SECTION 1. SUMMARY

1.1 BACKGROUND

A prototype facility for the disposal of unserviceable stockpiled chemical agents and munitions, designated as the Chemical Agent/Munition Disposal System (CAMDS), is being developed for use at the Tooele Army Depot, South Area, (TEAD-S), Utah. Operation of the facility may result in the discharge of low concentrations of air contaminants into the atmosphere from several 15-meter smoke stacks. Department of the Army guidelines for the disposal of such chemical agents and munitions specify that the discharge of air contaminants must conform to existing State and Federal emission and air quality standards. Additionally, the concentrations of agent present in the stack effluent must not exceed those specified for demilitarization operations. To comply with the Department of the Army guidelines, a system of stack monitors and air quality samplers will be employed to provide measurements of stack discharges and of ambient air quality at the perimeter of the disposal site.

Measurements of agent emissions will be made in real time, at the alarm level, for positive plant control and with bubblers to ensure compliance with the stringent emission standards adopted for the program. Eight sampling stations located around the perimeter of the disposal area (Figure 1-1) will measure ambient concentrations of total oxidants, suspended particulate, sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and agents GB and VX. Meteorological sensors located at the peripheral stations will measure wind speed and wind direction at the 4-meter level. The meteorological and air quality measurements at the eight stations will be recorded for documentation purposes. The stack emissions measurements will be available to the plant manager on a timely basis to provide current information on emission levels and the effectiveness of the air pollution control equipment.

This study was conducted to determine the meteorological aspects of potential air pollution problems at TEAD-S associated with stack discharges during the disposal operation. The specific objective was to develop reliable prediction methods to be used in conjunction with emissions data, meteorological data, and air quality measurements to ensure that the stack discharges during the disposal operation will not cause a significant deterioration of air quality or cause the State and Federal air quality standards and other standards imposed by the Army to be exceeded at the TEAD-S

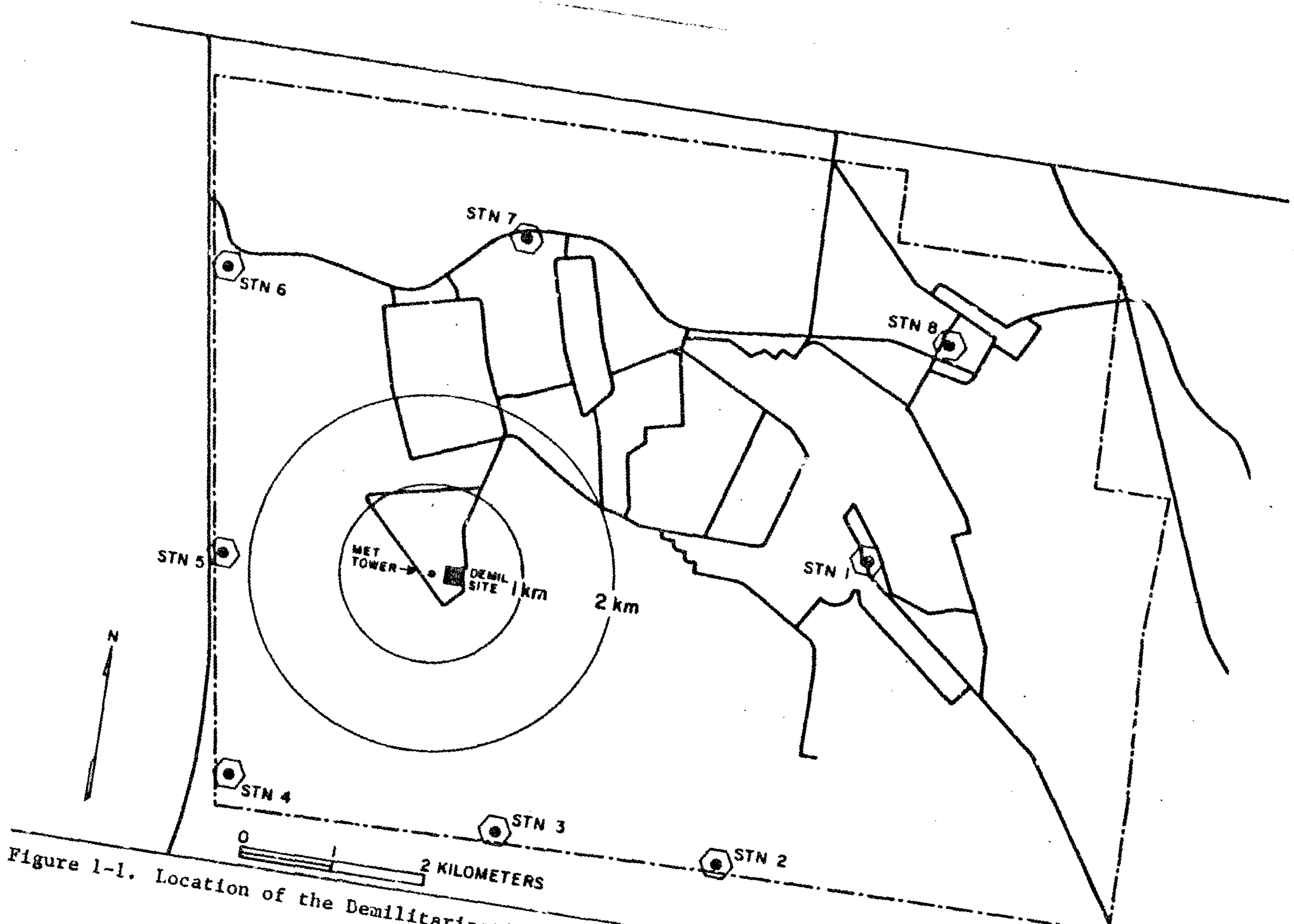

Figure 1-1. Location of the Demilitarization Site. The Dashed Lines Indicate the TEAD-S Boundar

boundaries. At the present time, the State of Utah has formally adopted air quality standards only for suspended particulates. The current Federal primary and secondary air quality standards for SO_2, particulates, carbon monoxide (CO), photochemical oxidants, hydrocarbons, and NO_2 are listed in Table 1-1.

The peripheral sampling network will be used to gather 1 year of ambient background concentrations of air pollutants prior to the start of the disposal operations. The information obtained will provide data concerning long-term ambient air quality after the disposal activities have begun. However, theoretical expectation and experience gained in monitoring ground-level concentrations produced by emissions from industrial stacks indicate that an eight-station sampling network of this type is incapable of measuring maximum ground-level concentrations for averaging times of 24 hours or less. The reason being that the angular width of the plume from the combined stack emissions is of the order of a few degrees, and the angular width of the wind direction sector occupied by the plume during short time periods (from, say, 1 to 24 hours) may range from 10 to 45 degrees. A very dense network of sampling stations certainly would be required to obtain accurate measurements of the maximum concentration.

The cost of providing a sampling network of sufficient density to determine compliance with short-term air quality standards would be prohibitive. Consequently, the primary objective of this study was to investigate the potential of using predictive mathematical models in conjunction with emissions and meteorological data to provide reliable estimates of maximum short-term ground-level concentrations at the TEAD-S boundaries.

1.2 TEST OBJECTIVE

The objective of this study was to develop and verify a mathematical prediction system which can be used to calculate maximum short-term ground-level concentrations at the boundaries of TEAD-S resulting from air contaminants emitted into the atmosphere during demilitarization operations. The system must be fully automated and designed for use by personnel having no specialized meteorological training. Further, the system must provide a high degree of confidence in the accuracy of the maximum concentrations calculated at the depot boundaries because the short-term Federal and State air quality standards are expressed in terms of concentrations that may not be exceeded more than once per year. On the other hand, the prediction system should not be so conservative that it will unreasonably restrict demilitarization operations.

Table 1-1. Federal Primary and Secondary Air Quality Standards*

Primary	Secondary
Sulfur Dioxide	**Sulfur Dioxide**
(a) 80 μg/m^3 - annual arithmetic (0.03 ppm) mean (b) 365 μg/m^3 - 24-hour maximum (0.14 ppm)	(a) 1300 μg/m^3 - 3-hour maximum (0.5 ppm)
Particulate Matter	**Particulate Matter**
(a) 75 μg/m^3 - annual geometric mean (b) 260 μg/m^3 - 24-hour maximum	(a) 60 μg/m^3 - annual geometric mean (b) 150 μg/m^3 - 24-hour maximum
Carbon Monoxide	**Carbon Monoxide**
(a) 10 mg/m^3 - 8-hour maximum (9 ppm) (b) 40 mg/m^3 - 1-hour maximum (35 ppm)	(a) 10 mg/m^3 - 8-hour maximum (9 ppm) (b) 40 mg/m^3 - 1-hour maximum (35 ppm)
Photochemical Oxidants	**Photochemical Oxidants**
160 μg/m^3 - 1-hour maximum (0.08 ppm)	160 μg/m^3 - 1-hour maximum (0.08 ppm)
Hydrocarbons	**Hydrocarbons**
160 μg/m^3 - 3-hour maximum (0.24 ppm) (6 to 9 a.m.)	160 μg/m^3 - 3-hour maximum (0.24 ppm) (6 to 9 a.m.)
Nitrogen Dioxide	**Nitrogen Dioxide**
100 μg/m^3 - annual arithmetic (0.05 ppm) mean	100 μg/m^3 - annual arithmetic (0.05 ppm) mean

*The Primary and Secondary Standards for 1, 3, and 24 hours are not to be exceeded more than once per year.

(The objectives of this program were modified somewhat from the original objectives because of experience gained from demilitarization operations at Rocky Mountain Arsenal as well as knowledge acquired concerning the specific character of dispersion at TEAD-S.)

1.3 SCOPE

A total of 35 1-hour releases of Fluorescent Particle (FP) tracer material were conducted at TEAD-S. The release height of the FP for all trials was 32 meters to approximate the effective release height of the buoyant plumes from the 15-meter stacks of the CAMDS. Rotorod samplers were located at 5-degree intervals at radial distances of 1 and 2 kilometers from the point of release, which is adjacent to the proposed disposal site. Tracer source strengths and meteorological measurements made during the trials were used to test and refine the prediction system. Maximum observed FP counts at each sampling arc, converted to dosages, were compared with the dosages calculated by the prediction system.

The majority of the trials were conducted under meteorological conditions which present particularly challenging situations because they are unfavorable for the successful application of diffusion models. Approximately one-half of the trials were conducted during light wind-speed situations. Trials were also conducted during transition periods with either increasing or decreasing low-level stability.

1.4 SUMMARY OF RESULTS

Based on diffusion models and on the climatology of TEAD-S and Dugway Proving Ground (DPG), a simplified prediction system was developed to calculate maximum short-term ground-level concentrations of pollutants at the boundaries of TEAD-S resulting from emissions from the CAMDS. In addition to a knowledge of stack parameters and source emission rates, the prediction system requires hourly average values of the mean wind speed at 32 meters, the 4-meter to 32-meter temperature difference, and the standard deviation of the wind azimuth angle at 16 meters.

The simplified prediction system was verified by comparing maximum observed FP counts expressed as dosages at 1 and 2 kilometers from point of emission, with calculated dosages for 31 of the 35 trials. The information obtained from four trials was not used because of insufficient meteorological data or because of inconsistencies in the sampling data. On the average, the calculated maximum dosages exceeded the observed maximum dosages at 2 kilometers

by a factor of about two. In one trial only did the observed dosage significantly exceed the calculated dosage; however, the meteorological conditions leading to the high observed counts for this trial were both unusual and transient. The sampler data also clearly showed that the eight peripheral monitoring stations will rarely, if ever, measure the maximum short-term ground-level concentrations at the depot boundaries.

The possibility of pooling (stagnation) was also investigated during the conduct of the trials. In nine of the trials, additional samplers were placed off the installation at locations known to have a potential for pooling. At only one sampling station was a moderate dosage detected; the level detected was considered to be insignificant. It was concluded that off-post pooling is unlikely to be a problem. However, there was evidence of possible pooling on the installation during several of the trials. Pooling is discussed in Appendix IV.

1.5 CONCLUSIONS

This study has shown that a simplified mathematical prediction system can be used to estimate, with a high degree of confidence, the maximum short-term ground-level concentrations of pollutants (at the TEAD-S boundaries) resulting from chemical agent/munition disposal operations. A model of this type is the most practical method for determining the maximum short-term concentrations at the depot boundaries.

The prediction system can be implemented either as a real-time system or as an off-line system (for estimating maximum ground-level concentrations that had existed at a preceding time). Either mode of operation will require that continuous meteorological measurements be made during disposal operations.

The real-time system model of operation will require a mini-computer to process the meteorological data and to perform the model concentration calculations, using source strengths obtained from the continuous stack measurements or developed during the initial checkout of the disposal facility. This mode of operation will provide the plant manager with a real-time method for estimating the impact of the disposal operation on ambient air quality. The real-time system could also be used to provide hazard predictions in the event of an accidential release of chemical agents during the handling and transportation phases of the operation.

A mini-computer could be used to perform the time averaging of concentration and meteorological data necessary to determine

compliance with the State and Federal air quality standards.

The off-line mode of operation would require continuous logging of the data from the meteorological tower and a complete record of source emissions data. The calculations would be performed by using historical data records in conjunction with the prediction model described in this report.

1.6 RECOMMENDATIONS

It is recommended that:

a. The simplified mathematical prediction system be employed during demilitarization operations to calculate the maximum short-term concentrations at the depot boundaries.

b. The instrumented meteorological tower installed for this study be retained for recording continuous meteorological measurements during actual disposal operations.

c. A mini-computer be used to perform the time averaging of concentration and meteorological data necessary to determine compliance with State and Federal air quality standards.

SECTION 2. DETAILS OF THE STUDY

2.1 TASK OBJECTIVES

The objectives of the meteorological study for TEAD-S were:

a. To simulate the buoyant emissions from the 15-meter stacks of the CAMDS by a series of 1-hour releases of FP tracer from a 32-meter tower located adjacent to the disposal site under a variety of meteorological conditions.

b. To measure ambient temperatures, wind speed, wind direction, and turbulence parameters during each trial.

c. To determine the crosswind profile of FP counts for each trial at downwind distances of 1 and 2 kilometers from the point of release.

d. To develop a prediction system to relate the FP source strength and the meteorological measurements to the maximum observed counts at the sampling arcs for each trial.

e. On the basis of the experience gained in completing Objective d, to develop a prediction system which can be used with a high degree of confidence to calculate maximum short-term ground-level concentrations at the boundaries of TEAD-S resulting from air contaminants emitted into the atmosphere during disposal operations. The system must be capable of being fully automated and of being used by personnel having no specialized meteorological training.

2.2 CRITERIA

2.2.1 Tracer Dissemination Rates

On the basis of model calculations, minimum FP tracer dissemination rates were specified for nighttime and daytime trials. These rates were approximately 6 grams per minute for nighttime releases and 30 grams per minute for daytime releases.

2.2.2 Meteorological Limitations

There were no meteorological restrictions for wind direction, relative humidity, air temperature, vertical temperature

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gradient, ground condition, or cloud cover. Tests were not conducted during periods of fog, frost, or precipitation. Table 2-1 lists the number of trials scheduled for each wind-speed category. As indicated by the table, emphasis was placed on the nighttime light wind conditions because this regime is unfavorable for the application of mathematical diffusion models.

Table 2-1. Number of Trials Desired in Each Wind-Speed Category.

Time of Day	Wind-Speed Category (m sec^{-1})			
	0-1.4	1.5-4.5	4.6-8.0	8.0
Daytime	3-5	3	3	1-2
Nighttime	12	3	3	1-2

2.3 SUPPLIES AND FACILITIES

2.3.1 Dissemination

An FP aerosol Skil Blower generator, Model V, was used for the dissemination of the tracer material.

2.3.2 Tracer Material

A blue-green zinc sulfide tracer (Lot H-1096) was used for nine trials, and two colors of zinc cadmium sulfide [green (Lot 782) and yellow (Lot 13)] were used for the remaining trials.

2.3.3 Sampling Equipment

The standard rotorod sampler, which was developed under the sponsorship of DPG, was utilized in this program. The samplers were remotely controlled by a transmitter-encoder located at each sampling station. The samplers were placed in pairs at each station, and by activating one rotorod surface per trial, four trials could be conducted before it became necessary to change the rotorods. Portable battery-operated, manually-controlled rotorod samplers were also used during some trials.

2.3.4 Meteorological Equipment

The 32-meter dissemination tower was instrumented with temperature sensors at the 1/2-, 4-, 16-, and 32-meter levels and with bivanes and cup anemometers at the 4-, 16-, and 32-meter levels.

An Automatic Data Acquisition System (ADAS) was installed at the test site to record data from the tower on magnetic tape. The data were also displayed on chart rolls at the site. In addition, wind direction and wind speed at the 2-meter level were measured at Stations 2 and 6 of the peripheral monitoring network (Figure 2-1) and were telemetered to the test site for display and recording. Pilot balloon (pibal) and surface weather observations were taken at the test site. Rawinsonde observations were taken at DPG and Salt Lake City on the day of each trial.

2.4 TEST PROCEDURES

2.4.1 Tracer Dissemination

For each trial, FP tracer was continuously disseminated from the 32-meter tower level for 1 hour. The dissemination hopper was checked for each trial and calibrated frequently during the test program. The total amount of tracer disseminated during each test was determined by weighing the hopper before and after dissemination. The efficiency of the Skil Blower system had been established from previous tests by using a vertical grid system and accounting for all of the material. The efficiency was determined to be 100 percent aerosolization.

2.4.2 Sampling Procedures

Figure 2-1 shows the location of the 72 rotorod samplers on each of the two sampling arcs as well as the eight peripheral sampling stations. Samplers on the inner arc were located at a radial distance of 1 kilometer from the dissemination/meteorological tower. Samplers 3 through 68 on the outer arc were located at a radial distance of 2 kilometers from the release point. Table 2-2 gives the radial distances to Samplers 69 through 2. It was necessary to locate these samplers beyond 2 kilometers in order to circumvent Area 10. All of the samplers on both arcs were positioned at 5-degree intervals.

The sampling network was activated at the start of dissemination, and sampling was terminated after the tracer plume was estimated to have completely passed the last downwind samplers. The time, in seconds, required for the trailing edge of the tracer plume to pass beyond 2 kilometers was estimated from the expression

$$t_p = \frac{2600}{\bar{u}_{4m}} \qquad (2\text{-}1)$$

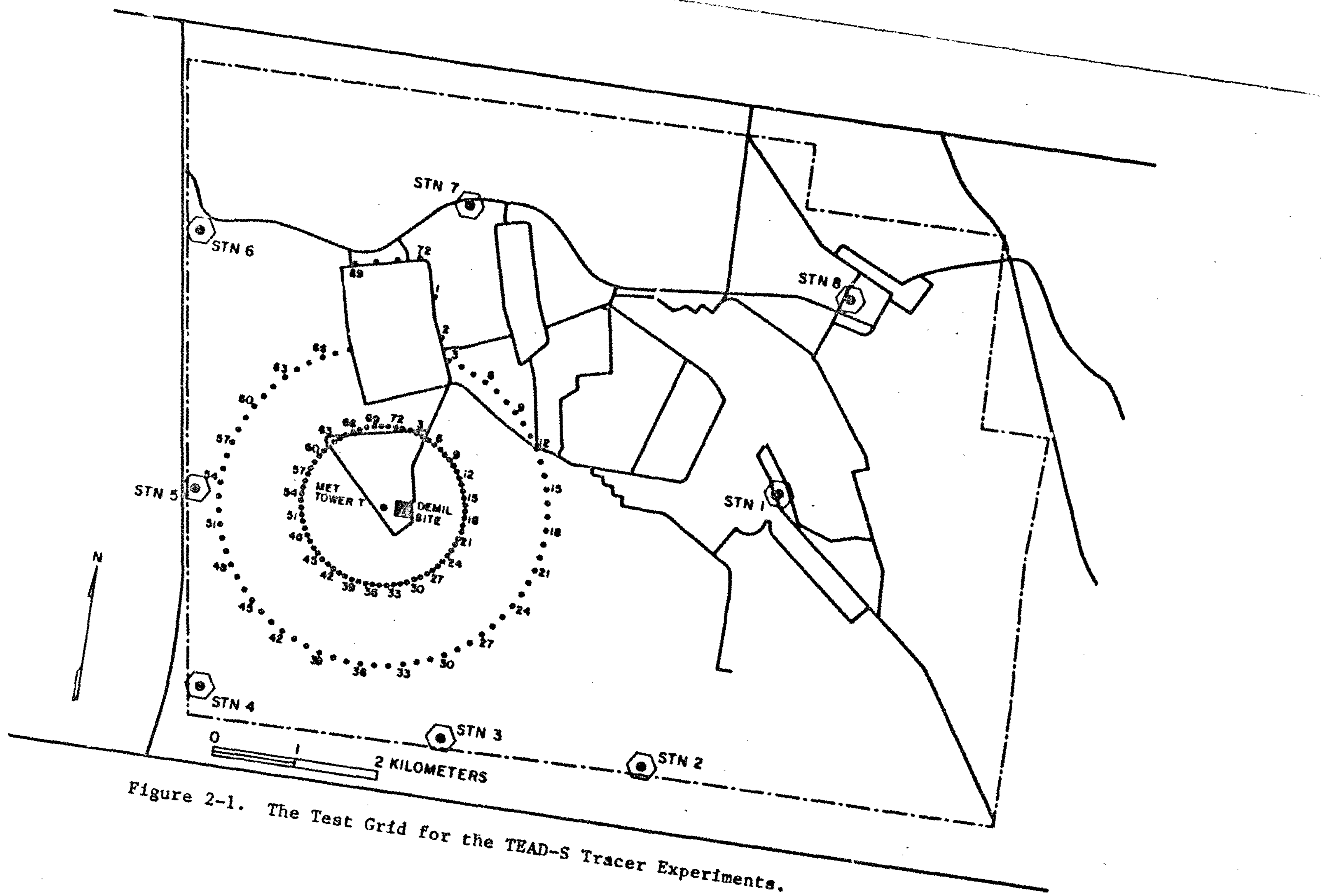


Figure 2-1. The Test Grid for the TEAD-S Tracer Experiments.

where $\bar{u}_{4m}$ is the mean wind speed in meters per second at the 4-meter level measured over the 10-minute period following the termination of FP dissemination. Adjustments to t_p were made if there was an increase or decrease in the 4-meter wind speed between the end of dissemination and the computed end of sampling time.

Table 2-2. Radial Distance to Samplers 69 Through 2 on the Second Sampling Arc.

Sampler Number	Radial Distance (Meters)
69	3000
70	3100
71	3100
72	3100
1	3000
2	2400

2.4.3 Meteorological Data Collection

All measurements obtained from the meteorological tower and Stations 2 and 6 were recorded on magnetic tape. All wind data were recorded at the rate of one reading per second from each channel. The temperature subsystem switched from level to level every 15 seconds. Thus, with temperature sensors at four tower levels, a complete cycle of the tower was made once each minute. The tape drives were initiated prior to the start of dissemination and were operated until the end of sampling.

2.5 DISCUSSION

2.5.1 Prediction System Selection

The dosage and concentration models that comprise the mathematical basis of the TEAD-S prediction system are contained in Appendix I. As depicted in Figure 2-1, the distances from the demilitarization area to the depot boundaries vary between 2 and 8 kilometers. At these distances, emissions from the 15-meter stacks will almost always be uniformly mixed in the vertical within the surface mixing layer. Thus, the box model given by Equation (I-10) in Appendix I was selected to predict ground-level concentrations

at the depot boundaries. The use of Equation (I-10) rather than Equation (I-1) eliminates the necessity for measuring the standard deviation of the wind elevation angle and simplifies the prediction system without any significant loss of accuracy in the concentrations calculated at the depot boundaries. In Figure 2-2, a comparison is made of concentration profiles calculated from the box model given by Equation (I-10) and the full model given by Equation (I-1). The profiles of the two models are shown to be in agreement beyond about 2 kilometers, the distance at which the effluent becomes uniformly mixed in the vertical.

2.5.2 Meteorological Parameters

In addition to a knowledge of stack parameters and pollutant emission rates, the simplified prediction system requires the following meteorological inputs:

a. Hourly mean wind speed $\bar{u}$ at 32 meters.

b. Hourly standard deviation of the wind azimuth angle σ_A at 16 meters.

c. Temperature difference ΔT between 4 and 32 meters.

These meteorological parameters are easily calculated from measurements made with conventional sensors mounted on the single 32-meter tower. The height of the surface mixing layer H_m may be inferred from ΔT and 32-meter wind speed on the basis of climatology for the site. To account for unusual meteorological conditions or system malfunctions, limits are set on the maximum height of the surface mixing layer and on the maximum hourly azimuth-angle standard deviations used as model inputs. These limits, which were determined from measurements made both at TEAD-S and DPG, are described below.

In the prediction system, the 4-meter to 32-meter temperature difference ΔT is used as the primary indicator of atmospheric stability and is interpreted as follows:

a. $\Delta T \geq +2°C$ - Very Stable. The bulk of the plume will tend to remain elevated and will come to the ground only by fumigation. The height of the surface mixing layer is set equal to the effective release height H for fumigation calculations.

b. $|\Delta T| < +2°C$ - Neutral. The plume will come to the ground by turbulent mixing. The mixing height is determined on the basis of the 32-meter wind speed as described in the following paragraph.

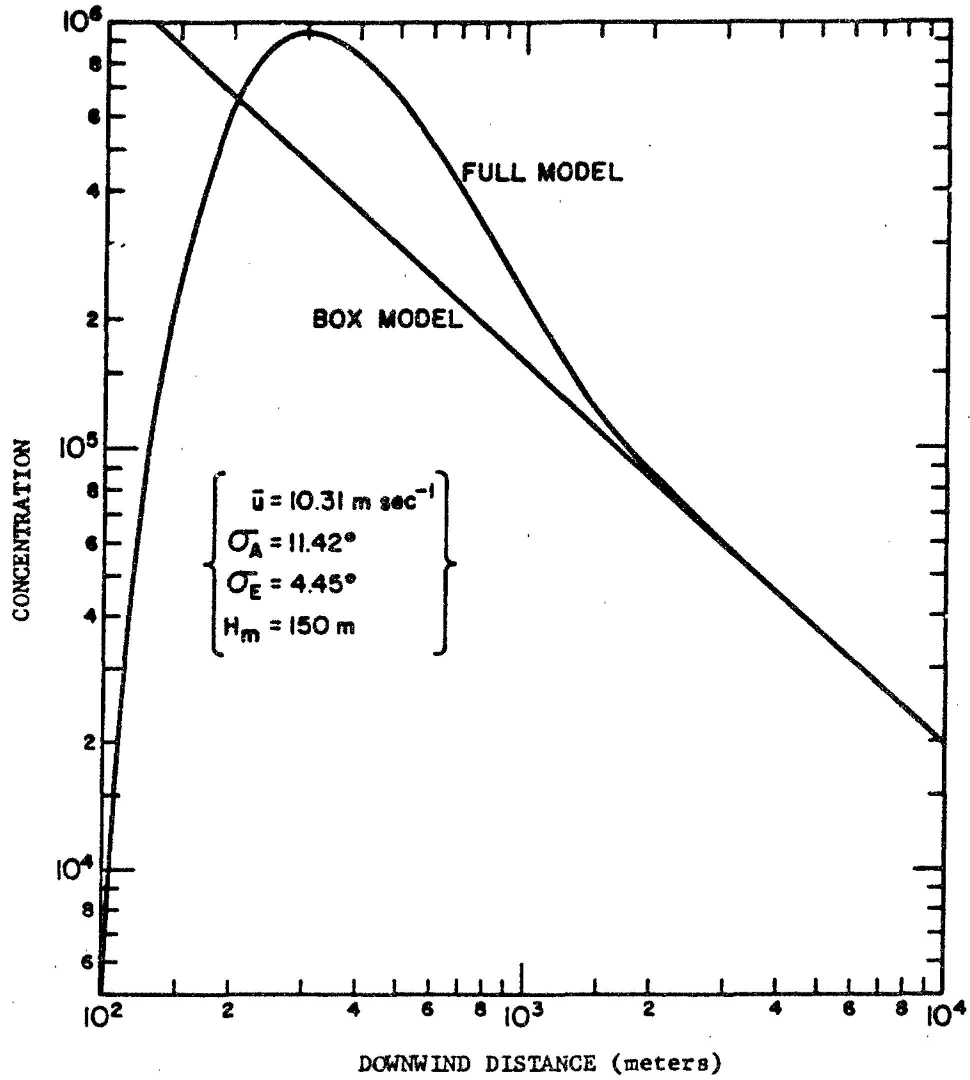


Figure 2-2. Comparison of Concentration Profiles Calculated by the Full Model Given by Equation (I-1) and the Box Model Given by Equation (I-10).

c. $\Delta T \leq -2°C$ - Very Unstable. The mixing height is set at 300 meters.

For the neutral stability category, the mixing height is determined from an empirical relationship between the 2-meter wind speed $\bar{u}_{2m}$ and H_m developed from DPG data [see Equation (3-3) of Cramer, et al., 1972][1]. This empirical expression is related to the 32-meter wind speed $\bar{u}_{32m}$ by a power law

$$\bar{u}_{32m} = \bar{u}_{2m}\left(\frac{32}{2}\right)^p \qquad (2\text{-}2)$$

with p set equal to 0.15. The resulting expression is

$$\log H_m \text{ (m)} = 1.18 + 0.1522\ \bar{u}_{32} \text{ (m sec}^{-1}) \qquad (2\text{-}3)$$

Equation (2-3) is restricted in that the mixing height may not be less than the effective release height H and may not exceed 150 meters. At first glance, the upper bound of 150 meters for H_m appears to be unnecessarily restrictive; however unusually shallow mixing height can occur at TEAD-S with high wind speeds at low levels. Figure 2-3 illustrates the relationship between H_m and $\bar{u}_{32m}$ used for the FP releases under neutral conditions.

For all stability categories, the standard deviation of the wind azimuth angle σ_A used in the calculations is not permitted to exceed 30 degrees. This value corresponds to the median hourly σ_A observed at the 4-meter level at TEAD-S for a wind speed of 1 meter per second.

2.5.3 Verification of the Prediction System

As discussed in Appendix I, the dosage model for a finite release and the concentration model for a continuous source have the same mathematical form. In the TEAD-S experiment, it was impractical to disseminate FP for a period sufficiently long to obtain hourly average concentrations resulting from a continuous source.

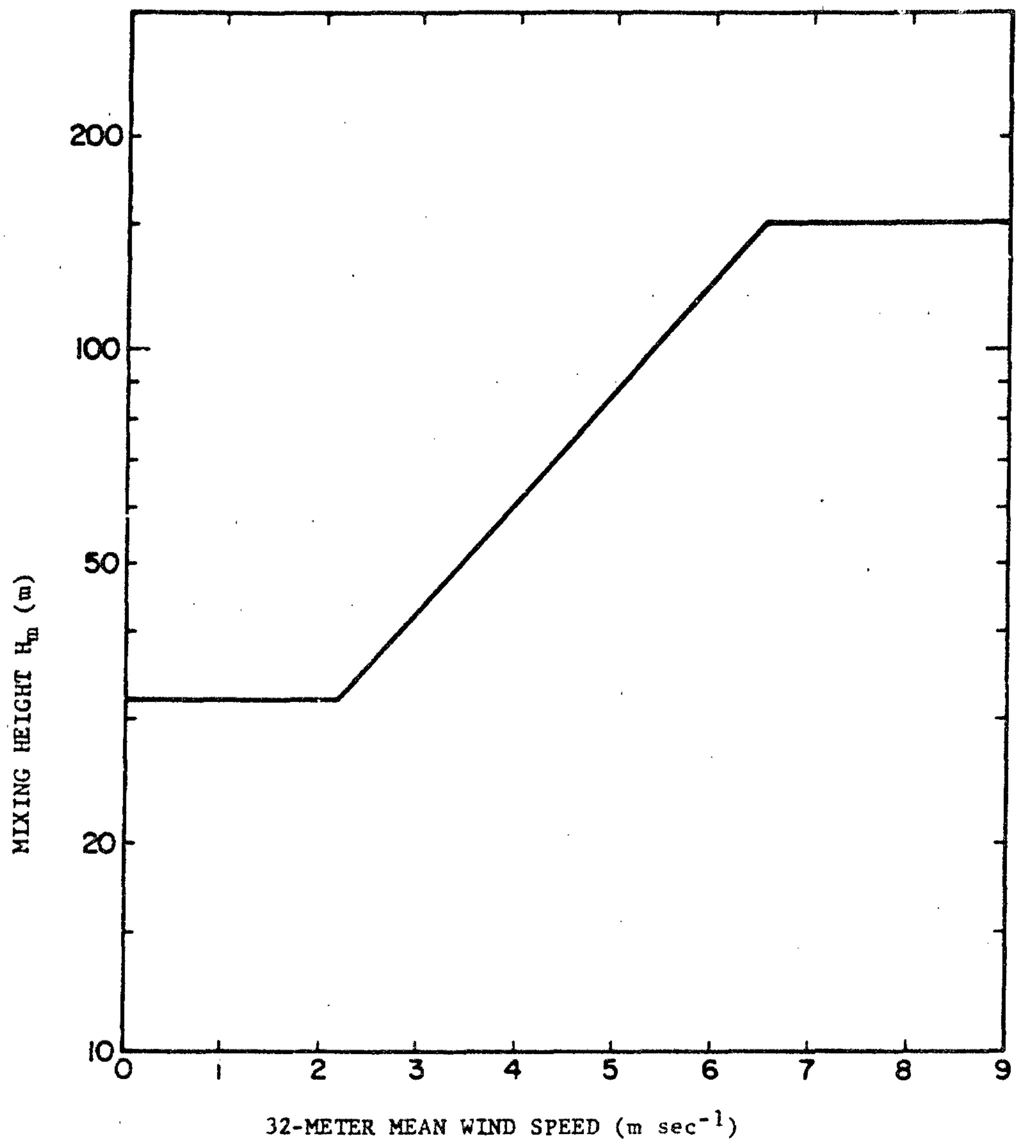


Figure 2-3. Relationship Between Mixing Height H_m and the 32-meter Wind Speed u_{32m} for the Neutral Stability Category of the TEAD Prediction System.

Thus, it was necessary to use the dosage form of the model to verify the prediction system. However, because of the mathematical similarity of the dosage and concentration models, verification of the prediction system for dosages should provide confidence in the prediction system for concentrations.

The prediction system was applied to 31 of the 35 FP trials, and the results were compared with the observed peak dosages at 1 and 2 kilometers. Trial B-1 was not used for comparison because of insufficient meteorological data. Trials B-4 and B-5 were deleted because in each case a preceding trial was conducted on the same day using the same color of FP tracer, thus making it impossible to determine which counts should be assigned to the second trial. Trial B-13R was also deleted because of rotorod malfunctions and inconsistencies in the sampler data. Brief descriptions of the 35 trials are contained in Appendix II.

2.5.4 Rotorod Data Analysis

The raw count data for all of the trials were plotted for visual inspection and analysis. A logarithmic smoothing process of the form

$$\bar{c}_i = \text{antilog} \; \frac{\log c_{i-1} + 2 \log c_i + \log c_{i+1}}{4} \qquad (2\text{-}4)$$

was also performed, where $\bar{c}_i$ is the smoothed count at the i^{th} sampler. The purpose of the smoothing was to obtain, by an objective method, a smoothed profile of representative continuous crosswind distributions. The plots of the smoothed counts at each arc for all trials are shown in Appendix III. Isopleth maps of observed counts are presented for selected trials in Appendix IV.

It should be noted that, with the exception of Samplers 69 through 2 on the second arc, all of the samplers on an arc are located at the same radial distance from the point of dissemination (Figure 2-1). The radial distances to Samplers 69 through 2 are listed in Table 2-2. Because the downwind distance varies for these adjacent samplers, the logarithmic smoothing process is not applicable in this area. The trials most affected, those with the peak count in the vicinity of these samplers, are Trials A-3, B-11, and B-12.

The peak smoothed and unsmoothed counts at each arc were converted to dosages by means of the relationship

$$D_p = \frac{c_p}{\text{(Aspiration Rate)(Sampling Efficiency)}} \tag{2-5}$$

The rotorod equivalent aspiration rate was 41.3 liters per minute (0.0413)cubic meters per minute). The sampling efficiency was determined by the type of FP used for a particular trial. Table 2-3 lists the sampling efficiency, the peak smoothed and unsmoothed counts at each arc for each trial. Smoothed peak counts and dosages are not given for the second arc for Trials A-3, B-11, and B-12 because, as previously noted, the peaks occurred near the area where the radial distance to the samplers was not standard. It should be noted that the smoothed peak counts and dosages are always less than the corresponding unsmoothed values.

2.5.5 Model Calculations

The simplified prediction system was used to calculate the peak dosages at 1 and 2 kilometers for each trial. In the case of Trial A-3, where the highest observed count on the second arc was located beyond 2 kilometers, the actual radial distance of 2400 meters to Sampler 2 was used as the calculation distance. In the model calculations, the initial lateral source dimension σ_{yo} was set equal to zero. That is, the source was treated as a point source. On the basis of previous experience, the lateral diffusion coefficient α was set equal to 0.9 and the distance X_{ry} over which rectilinear expansion occurs was set equal to 50 meters. Source strengths were determined by multiplying the total weight of the disseminated FP by the particle density (number of particles per unit weight) previously determined for each of the types of FP tracer. The dissemination efficiency was determined to be unity. The scaling coefficient K, required to change the units of the calculated dosages from particles-seconds per cubic meter to particles-minutes per cubic meter, is 1/60.

Table 2-4 lists the source and meteorological inputs used in the dosage calculations. Meteorological inputs include the mean wind speed at 32 meters and the standard deviation of the wind azimuth angle at 16 meters for the hour of tracer dissemination. The stability category was identified by the 4-meter to 32-meter temperature difference ΔT for the hour of dissemination. It should be noted that many trials were conducted during periods of light winds, and that the sampling often continued for several hours beyond the termination of dissemination.

Table 2-5 lists the calculated dosages at the two arcs for each trial. The stable trials are identified. The dosages calculated for these trials are the dosages that could occur if fumigation took place. The remainder of the trials are in the neutral stability category. No trials were conducted under unstable conditions.

Table 2-3. Sampling Efficiencies, Peak Unsmoothed and Smoothed Counts, and Peak Unsmoothed and Smoothed Dosages

Trial	Sampling Efficiency	Peak Count (Particles per rod)				Peak Dosage (p-min-m^{-3})			
		Unsmoothed		Smoothed		Unsmoothed		Smoothed	
		1 km	2 km	1 km	2 km	1 km	2 km	1 km	2 km
A-1	.64	107,000	52,680	103,441	38,391	4.052×10^{6}	1.995×10^{6}	3.917×10^{6}	1.474×10^{6}
A-2	.64	176,490	126,463	147,265	107,451	6.684×10^{6}	4.789×10^{6}	5.577×10^{6}	4.069×10^{6}
A-3	.64	117,725	149,303	108,452	---	4.458×10^{6}	5.654×10^{6}	4.107×10^{6}	---
A-4	.64	81,750	81,670	81,534	80,669	3.096×10^{6}	3.093×10^{6}	3.088×10^{6}	3.055×10^{6}
A-5	.76	197,760	19,400	134,834	19,259	6.307×10^{6}	6.187×10^{5}	4.300×10^{6}	6.142×10^{5}
A-6	.64	57	275	51	211	2.159×10^{3}	1.041×10^{4}	1.931×10^{3}	7.991×10^{3}
A-6R	.76	29,360	1,910	28,435	1,094	9.363×10^{5}	6.091×10^{4}	9.068×10^{5}	3.489×10^{4}
A-7	.64	81,876	60,644	72,911	58,551	3.101×10^{6}	2.297×10^{6}	2.761×10^{6}	2.217×10^{6}
A-7R	.72	105,575	46,810	102,384	43,214	3.554×10^{6}	1.576×10^{6}	2.447×10^{6}	1.455×10^{6}
A-8	.76	7,245	1,820	6,836	1,769	2.311×10^{5}	5.804×10^{4}	2.180×10^{5}	5.642×10^{4}
A-9	.72	12,300	2,225	10,912	2,159	4.141×10^{5}	7.490×10^{4}	3.673×10^{5}	7.270×10^{4}
A-10	.76	84,260	47,950	60,833	33,611	2.687×10^{6}	1.529×10^{6}	1.940×10^{6}	1.072×10^{6}
A-11	.76	8,270	1,690	6,168	1,576	2.637×10^{5}	5.390×10^{4}	1.967×10^{5}	5.026×10^{4}
B-1	.64	1,573	1,784	1,409	1,463	5.957×10^{4}	6.756×10^{4}	5.336×10^{4}	5.541×10^{4}
B-2	.64	227	695	196	573	8.597×10^{3}	2.632×10^{4}	7.423×10^{3}	2.170×10^{4}
B-3	.64	2,230	759	1,401	195	8.445×10^{4}	2.874×10^{4}	5.306×10^{4}	7.385×10^{3}

(Continued)

Table 2-3. (Concluded)

Trial	Sampling Efficiency	Peak Count (Particles per rod)				Peak Dosage ($p\text{-}min\text{-}m^{-3}$)			
		Unsmoothed		Smoothed		Unsmoothed		Smoothed	
		1 km	2 km	1 km	2 km	1 km	2 km	1 km	2 km
B-4	.76	5,606	67,242	5,057	63,343	1.788×10^{5}	2.144×10^{6}	1.613×10^{5}	2.020×10^{6}
B-5	.72	13,491	56,548	12,485	46,426	4.542×10^{5}	1.904×10^{6}	4.203×10^{5}	1.563×10^{6}
B-6	.76	9,786	9,456	9,553	9,004	3.121×10^{5}	3.016×10^{5}	3.047×10^{5}	2.872×10^{5}
B-7	.72	4,934	6,654	4,840	4,719	1.661×10^{5}	2.240×10^{5}	1.629×10^{5}	1.589×10^{5}
B-8	.76	21,710	13,125	18,569	11,411	6.924×10^{5}	4.186×10^{5}	5.922×10^{5}	3.639×10^{5}
B-9	.72	6,330	4,770	5,402	3,944	2.131×10^{5}	1.606×10^{5}	1.818×10^{5}	1.328×10^{5}
B-10	.72	62	1,335	56	1,274	2.087×10^{3}	4.494×10^{4}	1.885×10^{3}	4.289×10^{4}
B-11	.76	479	242	215	---	1.528×10^{4}	7.718×10^{3}	6.857×10^{3}	---
B-12	.72	112	4,550	75	—	3.770×10^{3}	1.532×10^{5}	2.525×10^{3}	---
B-12R	.76	52,950	22,440	50,937	22,016	1.689×10^{6}	7.157×10^{5}	1.624×10^{6}	7.021×10^{5}
B-13	.72	276	33,503	270	14,659	9.291×10^{3}	1.128×10^{6}	9.089×10^{3}	4.935×10^{5}
B-13R	.72	8,520	13,470	7,703	11.395	2.868×10^{5}	4.534×10^{5}	2.593×10^{5}	3.836×10^{5}
B-14	.72	20	99	19	58	6.733×10^{2}	3.333×10^{3}	6.396×10^{2}	1.952×10^{3}
B-15	.72	9	5,720	8	775	3.030×10^{2}	1.926×10^{5}	2.693×10^{2}	2.610×10^{4}
B-16	.76	421	4,943	368	4,476	1.343×10^{4}	1.576×10^{5}	1.174×10^{4}	1.427×10^{5}
B-17	.76	2,840	2,600	624	2,263	9.057×10^{4}	8.292×10^{4}	1.990×10^{4}	7.217×10^{4}
B-18	.76	95	1,465	66	975	3.030×10^{3}	4.672×10^{4}	2.105×10^{3}	3.109×10^{4}
B-19	.76	6,500	1,160	5,707	857	2.073×10^{5}	3.700×10^{4}	1.820×10^{5}	2.733×10^{4}
B-20	.72	11,324	6,036	10,542	1,120	3.812×10^{5}	2.032 x 10 [illegible]	3.549×10^{5}	3.770×10^{4}

Table 2-4. Source and Meteorological Inputs

Trial	Source Strength (Particles hr^{-1})	ΔT (°C)	$\bar{u}_{32m}$ (m sec^{-1})	σ_A 16m (deg)	H_m (m)
A-1	1.765×10^{13}	+2.4	0.6	30.0	32
A-2	1.895×10^{13}	+1.6	1.8	13.7	32
A-3	1.883×10^{13}	+0.7	1.4	21.6	32
A-4	1.786×10^{13}	+0.7	0.7	30.0	32
A-5	2.895×10^{13}	+2.0	2.7	10.5	32
A-6	1.821×10^{13}	+2.8	2.8	7.6	32
A-6R	2.229×10^{13}	+0.3	3.7	15.7	56
A-7	1.768×10^{13}	+0.9	2.0	10.9	32
A-7R	3.524×10^{13}	+3.8	1.7	30.0	32
A-8	2.355×10^{13}	-0.4	3.5	30.0	52
A-9	3.315×10^{13}	-0.2	4.4	19.7	71
A-10	2.481×10^{13}	-0.4	7.9	7.6	150
A-11	2.493×10^{13}	-0.8	9.2	30.0	150
B-2	1.665×10^{12}	+3.6	1.2	30.0	32
B-3	4.235×10^{12}	+2.0	1.5	30.0	32
B-6	6.601×10^{12}	-0.3	1.9	30.0	32
B-7	8.245×10^{12}	+1.4	2.1	30.0	32
B-8	5.138×10^{12}	-0.5	2.0	30.0	32
B-9	8.653×10^{12}	+0.4	1.7	16.0	32
B-10	6.469×10^{12}	+1.1	1.7	25.4	32

(Continued)

Table 2-4. (Concluded)

Trial	Source Strength (Particles hr^{-1})	ΔT (°C)	$\bar{u}_{32}$ (m sec^{-1})	σ_A 16m (deg)	H_m (m)
B-11	5.488×10^{12}	+3.0	4.0	17.4	32
B-12	7.002×10^{12}	+3.4	2.1	18.7	32
B12R	5.061×10^{12}	+2.6	1.5	30.0	32
B-13	8.182×10^{12}	+0.9	2.9	12.8	42
B-14	7.650×10^{12}	+1.4	5.0	5.0	87
B-15	7.587×10^{12}	+1.8	5.5	8.8	105
B-16	4.011×10^{12}	+0.9	5.1	9.4	90
B-17	4.935×10^{12}	+0.6	5.3	5.6	97
B-18	5.138×10^{12}	+1.0	5.5	12.6	105
B-19	5.915×10^{12}	-0.5	10.4	10.6	150
B-20	7.148×10^{12}	-0.6	11.4	5.3	150

Table 2-5. Results of the Dosage Calculations

Trial	Peak Dosage (p-min-m^{-3}) at Indicated Distance	
	1 Kilometer	2 Kilometers
[a]A-1	1.439×10^7	7.694×10^6
A-2	1.128×10^7	6.030×10^6
A-3	9.139×10^6	[b]4.145×10^6
A-4	1.248×10^7	6.674×10^6
[a]A-5	1.499×10^7	8.013×10^6
[a]A-6	1.256×10^7	6.715×10^6
A-6R	3.218×10^6	1.721×10^6
A-7	1.190×10^7	6.364×10^6
[a]A-7R	1.014×10^7	5.422×10^6
A-8	2.026×10^6	1.083×10^6
A-9	2.530×10^6	1.353×10^6
A-10	1.294×10^6	6.917×10^5
A-11	2.828×10^5	1.512×10^5
[a]B-2	6.788×10^5	3.629×10^5
[a]B-3	1.381×10^6	7.385×10^5
B-6	1.700×10^6	9.087×10^5
B-7	1.921×10^6	1.027×10^6
B-8	1.257×10^6	6.720×10^5
B-9	4.669×10^6	2.496×10^6
B-10	2.199×10^6	1.176×10^6
[a]B-11	1.157×10^6	6.187×10^5
[a]B-12	2.617×10^6	1.399×10^6
[a]B-12R	1.651×10^6	8.825×10^5
B-13	2.465×10^6	1.318×10^6

[a] Stable trials. Calculated dosages are the dosages which might occur as a result of fumigation.

[b] Calculation distance was 2.4 kilometers.

(Continued)

Table 2-5. (Concluded)

Trial	Peak Dosage (p-min-m^{-3}) at Indicated Distance	
	1 Kilometer	2 Kilometers
B-14	1.652×10^6	8.832×10^5
B-15	7.011×10^5	3.749×10^5
B-16	4.366×10^5	2.334×10^5
B-17	8.050×10^5	4.304×10^5
B-18	3.316×10^5	1.773×10^5
B-19	1.680×10^5	8.982×10^4
B-20	3.704×10^5	1.980×10^5

2.5.6 Comparison of Observed and Calculated Dosages

The calculated peak dosages have been compared with the peak unsmoothed and smoothed dosages at both sampling arcs. As previously noted, the simplified box model used for the dosage calculations is less likely to be representative at the 1-kilometer arc than it is at 2 kilometers and longer downwind distances. Since the prediction system will be applied at downwind distances of 2 to 3 kilometers, the results at the second arc are of primary concern.

In Table 2-6, a comparison is made of the unsmoothed and smoothed peak dosages (Table 2-3) with the calculated dosages (Table 2-5) for the nine stable trials. The observed to calculated ratio should be zero for these trials unless fumigation occurred. In this study, only those stable trials showing a ratio of 1/10 or greater were considered to be fumigation cases. The observed dosage is greater than or equal to 1/10 of the calculated fumigation dosage at one or both arcs for five of the nine trials (about 56 percent of the time). In those cases where the plume came down at 1 kilometer, the average observed to calculated ratio is 0.52 for the unsmoothed dosages and 0.47 for the smoothed dosages. At 2 kilometers, the corresponding ratios are 0.37 and 0.42. In no case did the observed fumigation dosage exceed the calculated fumigation dosage.

The trials conducted under very stable conditions indicate that fumigation can occur at TEAD-S. Trials A-1, A-5, A-7R, and B-12 were morning releases with sampling continuing for at least 1 hour beyond termination of dissemination. Fumigation is most

likely to occur during morning hours although Trial B-12R indicates that, with low-level releases, it may occasionally occur at night due to processes other than solar heating of the surface. The absence of significant counts at the outer arc for Trial A-5 may be an indication that the plume overrode a pocket of cold air. In the case of Trial B-12, fumigation probably occurred near the end of the sampling period when all of the FP had traveled beyond the 1-kilometer arc and much of it beyond the 2-kilometer arc.

The other stable trials (A-6, B-1, B-3, and B-11) were conducted during periods when fumigation would be least likely to occur. Trials B-3 and B-11 were conducted on clear nights. Trials A-6 and B-2 were morning releases; however, broken to overcast clouds prevented any significant solar heating and deepening of the surface mixing layer.

Table 2-6. Ratio of Observed to Calculated Peak Dosages for the Stable Trials

Trial	Observed to Calculated Ratio			
	Unsmoothed		Smoothed	
	1 Kilometer	2 Kilometers	1 Kilometer	2 Kilometers
A-1	0.28	0.26	0.27	0.19
A-5	0.42	0.08	0.29	0.08
A-6	0.00	0.00	0.00	0.00
A-7R	0.35	0.29	0.34	0.27
B-2	0.01	0.07	0.01	0.06
B-3	0.06	0.04	0.04	0.01
B-11	0.01	0.01	0.01	----
B-12	0.00	0.11	0.00	----
B-12R	1.02	0.81	0.98	0.80

In Table 2-7, the unsmoothed and smoothed peak dosages (Table 2-3) are compared with the calculated peak dosages (Table 2-5) for the 22 neutral trials. For all trials, the average observed to calculated ratio at 1 kilometer is 0.38 for the unsmoothed dosages and 0.32 for the smoothed dosages. At 2 kilometers, the corresponding ratios are 0.50 and 0.31. Thus, on the average, the simplified prediction system overestimates the observed dosage by a factor of about two at the 2-kilometer arc.

The observed unsmoothed peak dosage exceeds the calculated dosage at 2 kilometers for Trials A-3, A-10, and B-20. The observed smoothed peak dosage exceeds the calculated dosage at 2 kilometers only for Trial A-10. The difference between the calculated peak dosage and the unsmoothed observed peak dosage for Trial B-20 is less than 5 percent and is within the range of possible experimental error. A period of nearly calm winds followed by an approximate 180-degree wind shift probably accounts for the high observed dosage at the second arc for Trial A-3. There is a significant failure of the prediction system only in Trial A-10. A careful inspection of the meteorological data for Trial A-10 shows that the mixing height was only 75 meters, whereas the prediction system assigned a mixing height of 150 meters. Substitution of the correct mixing height would bring the observed and calculated dosages into very close agreement.

We believe that Trial A-10 represents an infrequent event that does not warrant lowering the maximum value of the mixing height from 150 meters, as assigned by the prediction system, to 75 meters. An inspection of Salt Lake City and DPG rawinsonde observations for that day shows that warm air was overriding a very shallow layer of cold air. A mixing height as low as 75 meters occurring simultaneously with a wind speed of 8 meters per second is a rare and probably very transient condition which should not occur more than several times per year. To alter the prediction system by a further lowering of the maximum possible mixing height would make the system unnecessarily restrictive.

There are nine neutral trials in which the observed unsmoothed dosage at 2 kilometers is less than 30 percent of the calculated dosage. In Trials A-6R, B-7, B-17, and B-18, inspection of pibal and tower data indicates that the actual mixing height exceeded the mixing height assigned by the prediction system leading to an overestimation of the peak dosage at 2 kilometers. Also, Trials B-9, B-10, and B-14 were evening or nighttime releases during which a shallow layer of cold air at the surface could have caused the majority of the FP tracer to override the samplers. There are no readily apparent explanations for the low observed dosages in

Table 2-7. Ratio of Observed to Calculated Peak Dosage for the Neutral Trials

Trial	Observed to Calculated Ratio			
	Unsmoothed		Smoothed	
	1 Kilometer	2 Kilometers	1 Kilometer	2 Kilometers
A-2	0.59	0.79	0.49	0.67
A-3	0.49	1.36	0.45	----
A-4	0.25	0.46	0.25	0.46
A-6R	0.29	0.04	0.28	0.02
A-7	0.26	0.36	0.23	0.35
A-8	0.11	0.05	0.11	0.05
A-9	0.16	0.06	0.15	0.05
A-10	2.08	2.21	1.50	1.55
A-11	0.93	0.36	0.70	0.33
B-6	0.18	0.33	0.18	0.32
B-7	0.09	0.22	0.08	0.15
B-8	0.55	0.62	0.47	0.54
B-9	0.05	0.06	0.04	0.05
B-10	0.00	0.04	0.00	0.04
B-13	0.00	0.86	0.00	0.37
B-14	0.00	0.00	0.00	0.00
B-15	0.00	0.51	0.00	0.07
B-16	0.03	0.67	0.03	0.61
B-17	0.11	0.19	0.02	0.17
B-18	0.01	0.26	0.01	0.18
B-19	1.23	0.41	1.08	0.30
B-20	1.03	1.03	0.96	0.19

Trials A-8 and A-9. However, since these two trials were conducted during a 3-hour period on the same day, this may have led to experimental difficulties with dissemination or sampling.

2.5.7 Advantages of the TEAD-S Prediction System and its Application to Other Sites

The diffusion model selected for the TEAD-S prediction system is a specialized form of the Gaussian plume model for a continuous elevated point source used by the Environmental Protection Agency (Turner, 1969)[2] and others. There are several important advantages of this specialized form. The use of the box-model concept mentioned above allows the vertical dimension of the plume at the TEAD-S boundaries to be fixed by one meteorological parameter i.e., the height of the surface mixing layer. Simple methods for calculating the height of the surface mixing layer from on-site temperature gradient and wind-speed measurements were developed during the TEAD-S study and are described in Section 2.5.2. Also, in the TEAD-S prediction model, the crosswind (lateral) plume dimension at the depot boundaries is directly calculated from on-site measurements of the hourly standard deviation of the azimuth wind-direction angle. Alternatively, in the modeling techniques described by Turner (1969)[2], the lateral and vertical plume dimensions are determined from sets of semi-empirical curves which apply strictly to 10-minute averaging times (rather than hourly) and are principally based on limited measurements made in fair weather at relatively short distances downwind from ground-level sources. It is generally recognized that use of directly-measured meteorological parameters to predict lateral and vertical plume dimensions is much preferred over the use of the standard expansion curves given by Turner (1969)[2].

The general form of the simplified diffusion model selected for the TEAD-S prediction system is applicable at other sites provided the minimum distance from the source to the site boundaries is of the order of 2 kilometers and the effective source height is not greatly increased. If these conditions are not satisfied, appropriate modifications could easily be made in the model format to accomodate new source parameters and/or shorter downwind distances. The values of the surface mixing height, hourly standard deviation of azimuth wind direction and other meteorological predictors determined for TEAD-S are not generally applicable to other sites. Appropriate values of these parameters are best determined at each site from a limited meteorological measurement program and a review of the site climatology and topography. Except for sites with extremely complex terrain, the level of effort required to develop appropriate prediction-model formats and meteorological inputs is small compared to the effort required for the TEAD-S study and does not involve releases of tracer material.

SECTION 3. APPENDICES

APPENDIX I. DOSAGE AND CONCENTRATION MODELS

The centerline ground-level dosage at downwind distance x produced by an elevated point or volume source is given by

$$D\{x,0,0\} = \frac{K\,Q}{\pi\,\bar{u}\,\sigma_y\,\sigma_z}\left\{\exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] + \sum_{i=1}^{\infty}\left[\exp\left[\frac{-(2iH_m-H)^2}{2\sigma_z^2}\right]\right.\right.$$

$$\left.\left. + \exp\left[\frac{-(2iH_m+H)^2}{2\sigma_z^2}\right]\right]\right\} \qquad \text{(I-1)}$$

where

Q = the source strength

σ_y,σ_z = the standard deviations of the lateral and vertical concentration distributions

$\bar{u}$ = the mean wind speed

K = a scaling coefficient to convert input parameters to dimensionally consistent units

H_m = the height of the surface mixing layer

H = the effective release height of the source

The standard deviation of the lateral concentration distribution σ_y is given by

$$\sigma_y = \sigma_A'\{\tau\}\,x_{ry}\left[\frac{x + x_y - x_{ry}(1-\alpha)}{\alpha\,x_{ry}}\right]^{\alpha} \qquad \text{(I-2)}$$

and

$$x_y = \begin{cases} \dfrac{\sigma_{yo}}{\sigma'_A\{\tau\}} - x_{Ry} & ; \sigma_{yo} \leq \sigma'_A\{\tau\}\, x_{ry} \\ \alpha x_{ry} \left(\dfrac{\sigma_{yo}}{\sigma'_A\{\tau\}\, x_{ry}}\right)^{1/\alpha} - x_{Ry} + x_{ry}(1-\alpha) & ; \sigma_{yo} > \sigma'_A\{\tau\}\, x_{ry} \end{cases} \tag{I-3}$$

where

σ_{yo} = the standard deviation of the lateral concentration distribution at a downwind distance x_{Ry} from the source

x_{ry} = the downwind distance from the virtual point source over which rectilinear lateral expansion occurs

α = the lateral diffusion coefficient

$\sigma'_A\{\tau\}$ = the standard deviation of the wind azimuth angle in radians measured over the emission time τ

The standard deviation of the vertical concentration distribution σ_z is given by

$$\sigma_z = \sigma'_E\, x_{rz} \left[\frac{x + x_z - x_{rz}\,(1-\beta)}{\beta\, x_{rz}}\right]^{\beta} \tag{I-4}$$

Where σ'_E is the standard deviation of the wind elevation angle in radians and β is the vertical diffusion coefficient. The other terms in Equation (I-4) are analogous to those in Equations (I-2) and (I-3).

For a thermally buoyant source, the effective release height H is equal to the sum of the actual stack height h and the buoyant rise Δh. Briggs (1970, 1972)(3,4) defines the buoyant rise Δh by

$$\Delta h = \begin{cases} 7.469\left(\dfrac{F}{h}\right)^{1/3} & ; \dfrac{\partial\theta}{\partial z} \leq 0 \\ 2.4\left(\dfrac{F}{\bar{u}\, S}\right)^{1/3} & ; \dfrac{\partial\theta}{\partial z} > 0 \end{cases} \tag{I-5}$$

where

$$F = \frac{gV\,T_a}{T_s\,\pi}\left[\left(1 - \frac{M_s}{M_a}\right) + \left(\frac{T_s}{T_a} - 1\right)\left(\frac{c_{ps}\,M_s}{c_{pa}\,M_a}\right)\right] \qquad \text{(I-6)}$$

$$S = \frac{g}{T_a}\frac{\partial\theta}{\partial z} \qquad \text{(I-7)}$$

V = the volumetric emission rate of the stack

g = the acceleration due to gravity

T_a = the ambient air temperature (°K)

T_s = the stack exit temperature (°K)

M_a = the molecular weight of air

M_s = the molecular weight of the stack gas

c_{pa} = the specific heat of air

c_{ps} = the specific heat of the stack gas

$\frac{\partial\theta}{\partial z}$ = the ambient vertical gradient of potential temperature

The standard deviation of the lateral concentration distribution σ_{yo} at the downwind distance of plume stabilization x_{Ry} is given by

$$\sigma_{yc} = \frac{(0.5)\,\Delta h}{2.15} \qquad \text{(I-8)}$$

where

$$x_{Ry} = \begin{cases} 10\,h & ; \ \frac{\partial\theta}{\partial z} \le 0 \\ \pi\,\bar{u}\,S^{-1/2} & ; \ \frac{\partial\theta}{\partial z} > 0 \end{cases} \qquad \text{(I-9)}$$

The infinite series term in Equation (I-1) acts to change the form of the vertical concentration distribution from Gaussian to rectangular at long downwind distances where the source becomes uniformly mixed in the surface mixing layer. At these distances, an equivalent expression for Equation (I-1) is

$$D\{x,0,0\} = \frac{K\,Q}{\sqrt{2\pi}\;\bar{u}\;\sigma_y\;H_m} \tag{I-10}$$

Equations (I-1) and (I-10) may also be used to calculate the centerline ground-level concentration at downwind distance x produced by an elevated continuous point or volume source. In order to calculate concentration, the source emission rate $\dot{Q}$ must be substituted for the source strength Q and $\sigma'_A\{\tau\}$ must be measured over the desired concentration averaging time.

APPENDIX II. TRIAL SUMMARIES

This Appendix contains brief descriptions of the 35 FP tracer trials. Each description includes date of each trial, dissemination and sampling times, ground conditions, sky cover, 4-meter to 32-meter temperature difference, estimated mixing height, and a brief summary of the low-level wind conditions observed throughout the trial.

Trial: A-1 Date: 2 February 1973

Dissemination: 1035-1135 MST Sampling: 1020-1300 MST

Sky Cover (tenths): 9 to 10

Ground Condition: Snow Covered

4-32 meter ΔT (^{o}C): + 2.4

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind at the start of the trial was from the southeast at about 1 meter per second and shifted to the northwest at 1125 MST. Pibals showed southeast winds at about 3 meters per second at a height of 40 meters throughout the trial.

Trial: A-2 Date: 5 February 1973

Dissemination: 1230-1330 MST Sampling: 1228-1415 MST

Sky Cover (tenths): 4 to 5

Ground Condition: Snow Covered

4-32 Meter ΔT (^{o}C): + 1.6

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the southeast at about 1 meter per second at the start of the trial, increasing to 4 to 5 meters per second by 1400 MST. Pibals also showed low-level winds from the southeast through south with wind speeds increasing throughout the sampling period.

Trial: A-3	Date: 7 February 1973
Dissemination: 0907-1007 MST	Sampling: 0903-1115 MST

Sky Cover (tenths): 10

Ground Condition: Snow Covered

4-32 Meter ΔT (^oC): + 0.7

Estimated Mixing Height (m): 150 decreasing to 40

Remarks:

Occasional light snow fell during this trial. The 32-meter wind was from the northwest at 1 to 2 meters per second at the start of the trial, calm at 0950 MST, variable from southeast to northeast at less than 1 meter per second by 1014 MST, switching to the north-northeast at 1034 MST and to the north-northwest by 1045 MST. Pibals also showed low-level winds initially from the northwest switching to the southeast at 1037 MST and returning to the north-northwest by 1107 MST.

Trial: A-4	Date: 13 February 1973
Dissemination: 0918-1018 MST	Sampling: 0910-1114 MST

Sky Cover (tenths): 2 (Cirrus)

Ground Condition: Mostly snow covered; southern portion of grid covered by water

4-32 Meter ΔT (^oC): + 0.7

Estimated Mixing Height (m): 200

Remarks:

The 32-meter wind was from the southeast throughout the trial with an average speed of about 1 meter per second. Low-level wind speeds increased slightly towards the end of the sampling period.

Trial: A-5 | Date: 26 April 1973

Dissemination: 0610-0710 MST | Sampling: 0610-0830 MST

Sky Cover: Clear, but hazy

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 2.0

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was from the south-southeast at about 1 meter per second from 0610 to 0720 MST. At this time, the speed decreased and the direction became quite variable, although still generally from the south-southeast. Pibals showed light winds from the southeast near the surface throughout the trial.

Trial: A-6 | Date: 31 January 1973

Dissemination: 0910-1010 MST | Sampling: 0831-1110 MST

Sky Cover (tenths): 7 tc 8

Ground Condition: Snow covered

4-32 Meter ΔT (^{o}C): + 2.8

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was from the east through southeast at 1 to 2 meters per second from 0910 to 1040 MST. At this time, the wind became calm and then switched to the northwest at about 2 meters per second. Pibals also showed an approximate 180-degree wind shift near the surface between the start of dissemination and the end of sampling.

Trial: A-6R Date: 8 May 1973

Dissemination: 0905-1005 MDT Sampling: 0904-1019 MDT

Sky Cover (tenths): 6

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.3

Estimated Mixing Height (m): 150

Remarks:

A strong nocturnal inversion was dissipated by release time. The 32-meter wind was from the southeast at 3 to 4 meters per second throughout the trial. Pibals showed winds from the southeast up to 150 meters with winds from the southwest above 150 meters.

Trial: A-7 Date: 1 February 1973

Dissemination: 1156-1256 MST Sampling: 1150-1433 MST

Sky Cover (tenths): 1 to 3

Ground Condition: Snow covered

4-32 Meter ΔT (^{o}C): + 0.9

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the northwest at 2 meters per second at the start of the trial. The speed dropped below 1 meter per second at 1256 MST with the direction apparently shifting to the southeast. Pibals also reflected a wind shift from north-northwest to southeast near the surface.

Trial: A-7R **Date:** 15 May 1973

Dissemination: 0627-0727 MDT **Sampling:** 0630-1000 MDT

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (°C): + 3.8

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind fluctuated from southeast to southwest with speeds of 1 to 3 meters per second. The ADAS system was inoperative during the periods 0741 to 0747 and 0818 to 0820 MDT. Pibals also showed winds from the southeast through southwest at 1 to 3 meters per second at about 40 meters throughout the trial.

Trial: A-8 Date: 4 April 1973

Dissemination: 1400-1500 MST Sampling: 1345-1520 MST

Sky Cover (tenths): 1

Ground Condition: Dry

4-32 Meter ΔT (°C): - 0.4

Estimated Mixing Height (m): 150

Remarks:

Northwest winds at 2 to 4 meters per second prevailing throughout the trial at the 32-meter level.

Trial: A-9

Date: 4 April 1973

Dissemination: 1526-1626 MST

Sampling: 1522-1646 MST

Sky Cover (tenths): 1 to 2

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.2

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind fluctuated from northwest through north at 3 to 4 meters per second at the start of the trial with the speed increasing to about 6 meters per second by 1616 MST.

Trial: A-10

Date: 4 April 1973

Dissemination: 1747-1847 MST

Sampling: 1744-1907 MST

Sky Cover (tenths): 4 to 7

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.4

Estimated Mixing Height (m): 75

Remarks:

Northwest winds at 8 to 9 meters per second prevailed at the 32-meter level from 1747 to 1817 MST, decreasing to 5 to 6 meters per second at this time. Pibals also showed moderate to strong northwest winds near the surface with the height of the maximum wind speed varying from 150 to 40 meters.

Trial: A-11

Date: 31 May 1973

Dissemination: 1532-1632 MDT

Sampling: 1529-1632 MDT

Sky Cover (tenths): 6 to 10

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.8

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the southeast through southwest at 6 meters per second from the start of dissemination until 1612 MDT when the 32-meter wind shifted to west at 12 meters per second. Pibals showed low-level winds switching from southeast to west to northwest during the trial.

Trial: B-1

Date: 24 January 1973

Dissemination: 0650-0750 MST

Sampling: 0340-0920 MST

Sky Cover: Clear, but hazy

Ground Condition: Snow covered

4-32 Meter ΔT (^{o}C): Missing

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was light and variable throughout the test period. Pibals showed light winds from the southeast through southwest above 40 meters.

Trial: B-2 Date: 29 January 1973

Dissemination: 0713-0813 MST Sampling: 0706-0930 MST

Sky Cover (tenths): 10

Ground Condition: Frozen

4-32 Meter ΔT (^{o}C): + 3.6

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was from the southeast at about 1 meter per second throughout this trial.

Trial: B-3 Date: 13 February 1973

Dissemination: 0527-0627 MST Sampling: 0518-0652 MST

Sky Cover (tenths): 0 to 1 (Cirrus)

Ground Condition: Snow covered

4-32 Meter ΔT (^{o}C): + 2.0

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was from the east through southeast at about 2 meters per second from 0527 until about 0620 MST when the direction changed to north-northeast. Pibals showed winds at 40 meters to be from the southeast or south throughout the trial.

Trial: B-4 | Date: 26-27 March 1973

Dissemination: 2307-0007 MST | Sampling: 2304-0218 MST (includes Trial B-5)

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.4

Estimated Mixing Height (m): 30-40

Remarks:

Trial B-13 was conducted earlier in the day using the same color of FP as for Trial B-4. Pibals showed the wind at 40 meters to be from the southeast at 2 meters per second at 2310 MST becoming nearly calm at 2340 MST and switching to the northwest at 1 meter per second by 0018 MST. Since the low-level winds for Trial B-13 were from the north until 2150 MST before switching to the southeast, some FP from Trial B-13 may have been recorded in Trial B-4, especially at the second arc.

Trial: B-5 | Date: 27 March 1973

Dissemination: 0018-0118 MST | Sampling: 2304-0218 MST (includes Trial B-4)

Sky Cover (tenths): 3

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 2.3

Estimated Mixing Height (m): 30-40

Remarks:

Trial B-16 was conducted earlier in the day using the same color of FP. The wind at 32 meters was northwest at about 1 meter per second throughout the trial. The FP cloud from Trial B-16 probably traveled south, then to the northwest and finally turned toward the southeast at the start of sampling for this trial. Because of the early sampler turn on, FP from Trial B-16 may have contributed to counts observed in Trial B-5, especially at the 2-kilometer arc.

Trial: B-6 | Date: 9 April 1973

Dissemination: 1930-2030 MST | Sampling: 1928-2049 MST

Sky Cover (tenths): 8 to 10

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.3

Estimated Mixing Height (m): 75

Remarks:

The 32-meter wind was quite variable with the direction changing from northwest at 1930 MST to north at 1940 MST, to northeast at 1950 MST, and to southeast at 2020 MST. Pibals showed a similar variability in the wind directions near the surface.

Trial: B-7 | Date: 9 April 1973

Dissemination: 2048-2148 MST | Sampling: 2049-0107 MST

Sky Cover (tenths): 5 to 10

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.4

Estimated Mixing Height (m): 75-40

Remarks:

The 32-meter wind was from the southeast at 2040 MST, southwest at 2100 MST, northwest at 2110 MST, north at 2120 MST and northwest after 2130 MST. The wind speeds remained at 1 to 2 meters per second throughout the sampling period. Pibals showed a similar variability in the low-level winds.

Trial: B-8 Date: 10 April 1973

Dissemination: 1955-2055 MST Sampling: 1948-2130 MST

Sky Cover (tenths): 9

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.5

Estimated Mixing Height (m): 40

Remarks:

The wind at the 32-meter level remained from the northwest throughout the trial with the speed increasing from about 1 meter per second at the start of dissemination to about 4 meters per second at 2105 MST.

Trial: B-9 Date: 10 April 1973

Dissemination: 2222-2322 MST Sampling: 2221-0010 MST

Sky Cover (tenths): 9

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.4

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind varied from west through north-northwest at 1 to 2 meters per second throughout the trial.

Trial: B-10 Date: 26 April 1973

Dissemination: 0420-0520 MST Sampling: 0417-0610 MST

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.1

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind was from the south at about 1 meter per second from the start of dissemination until 0550 MST. At this time, the wind became light and variable with the wind generally from the east. The ADAS system was inoperative from 0450 to 0455 MST.

Trial: B-11 Date: 8 May 1973

Dissemination: 0316-0416 MDT Sampling: 0304-0540 MDT

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 3.0

Estimated Mixing Height (m): 30-40

Remarks:

The wind near the surface was very light while the wind at 32 meters was from the southeast at 3 to 4 meters per second throughout the trial.

Trial: B-12 Date: 8 May 1973

Dissemination: 0553-0653 MDT Sampling: 0551-0825 MDT

Sky Cover (tenths): 0 to 5

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 3.4

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the southeast at about 2 meters per second throughout the trial. The strong nocturnal inversion present during dissemination was dissipated by 0752 MDT.

Trial: B-12R Date: 15 May 1973

Dissemination: 0402-0502 MDT Sampling: 0352-0630 MDT

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 2.6

Estimated Mixing Height (m): 30-40

Remarks:

The 32-meter wind, initially from the southeast at 1 meter per second, became variable at 0422, switched to north at less than 1 meter per second at 0452 and then veered to the northeast at 1 to 2 meters per second at 0532 MDT. Pibals showed the same variability in the wind speed and wind direction at 40 meters. The ADAS was inoperative from 0442 to 0445 and from 0550 to 0602 MDT.

Trial: B-13

Date: 26 March 1973

Dissemination: 2041-2141 MST

Sampling: 1925-2304 MST(no. half)
2020-2304 MST(so. half)
(includes Trial B-16)

Sky Cover: Clear

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.9

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the northwest at 2 to 3 meters per second from the start of dissemination until 2150 MST when the direction changed to the southeast.

Trial: B-13R

Date: 4 April 1973

Dissemination: 1912-2012 MST

Sampling: 1911-2052 MST

Sky Cover (tenths): 3 to 4

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.8

Estimated Mixing Height (m): 150

Remarks:

Trial A-9 was conducted earlier in the day with the same color of FP. The 32-meter wind was from the northwest at 4 meters per second at the start of dissemination with speeds decreasing to 2 to 3 meters per second by 2012 MST. At 2022, the 32-meter wind shifted to the northeast at 1 to 2 meters per second. The ADAS System was inoperative from 1940 to 1942 MST.

Trial: B-14

Date: 29 March 1973

Dissemination: 2006-2106 MST

Sampling: 1852-2206 MST (so. half)
2057-2206 MST (no. half)
(includes Trial B-17)

Sky Cover (tenths): 0 to 7

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.4

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the northwest at 4 to 5 meters per second at the start of dissemination with wind speeds decreasing to 2 to 3 meters per second at the end of sampling.

Trial: B-15

Date: 29-30 March 1973

Dissemination: 2336-0036 MST

Sampling: 2228-0122 MST

Sky Cover (tenths): 0 to 1

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.8

Estimated Mixing Height (m): 150

Remarks:

Trial B-14 was conducted prior to this trial using the same color of FP. The 32-meter wind was from the northwest at about 6 meters per second at the start of dissemination with speeds decreasing during the sampling period.

Trial: B-16 | Date: 26 March 1973

Dissemination: 1928-2028 MST

Sampling: 1925-2145 MST(so. half)
2020-2145 MST(no. half)
(includes portion of Trial B-13)

Sky Cover (tenths): 2

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.9

Estimated Mixing Height (m): 150

Remarks:

The 32-meter wind was from the northwest at about 5 meters per second from 1928 MST until about 2140 MST. At this time, the speeds decreased and the wind direction changed to the east, persisting until 2250 MST when the direction changed to southeast. The 32-meter wind switched to the northeast at about 2330 MST. The probable net effect of the changes in wind direction was to bring the FP cloud back over the 2-kilometer sampling arc after the cloud had earlier passed beyond the arc.

Trial: B-17 | Date: 29 March 1973

Dissemination: 1900-2000 MST

Sampling: 1852-2206 MST(so. half)
2057-2206 MST(no. half)
(includes portion of Trial B-14)

Sky Cover (tenths): 0 to 7

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 0.6

Estimated Mixing Height (m): 150

Remarks:

Steady northwest winds at 3 to 6 meters per second prevailed throughout the trial at the 32-meter level.

Trial: B-18 Date: 29-30 March 1973

Dissemination: 2230-2330 MST Sampling: 2218-0122 MST (Includes Trial B-15)

Sky Cover (tenths): 0 to 7

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): + 1.0

Estimated Mixing Height (m): 150

Remarks:

Trial B-17 was conducted prior to this trial using the same color of FP. At the 32-meter level the wind was from the northwest at 4 to 6 meters per second until about 0100 MST when the speed began to decrease, lowering to less than 1 meter per second by 0130.

Trial: B-19 Date: 28 March 1973

Dissemination: 1925-2025 MST Sampling: 1923-2036 MST

Sky Cover (tenths): 10

Ground Condition: Dry

4-32 Meter ΔT (^{o}C): - 0.5

Estimated Mixing Height (m): 75

Remarks:

The 32-meter wind was from the north-northwest at about 10 meters per second throughout the trial. Light snow began to fall at approximately 2020 MST with strong winds and moderate snow after the end of sampling and prior to rotorod pickup.

Trial: B-20 **Date:** 28 March 1973

Dissemination: 2232-2332 MST **Sampling:** 2212-2341 MST

Sky Cover (tenths): 10

Ground Condition: Dry, but with light snow falling

4-32 Meter ΔT ($^{\circ}C$): - 0.6

Estimated Mixing Height (m): 75

Remarks:

The 32-meter wind was from the northwest at about 11 meters per second throughout the trial. Light snow fell throughout dissemination and sampling. Moderate snow and high winds occurred after the termination of sampling, but prior to the collection of the rotorods.

APPENDIX III. SMOOTHED CROSSWIND COUNT PROFILES

This Appendix contains log-smoothed crosswind profiles of total observed counts at the 1-kilometer (A) and 2-kilometers (B) arcs for each trial. The smoothing procedures are described in detail in Paragraph 2.5.4.

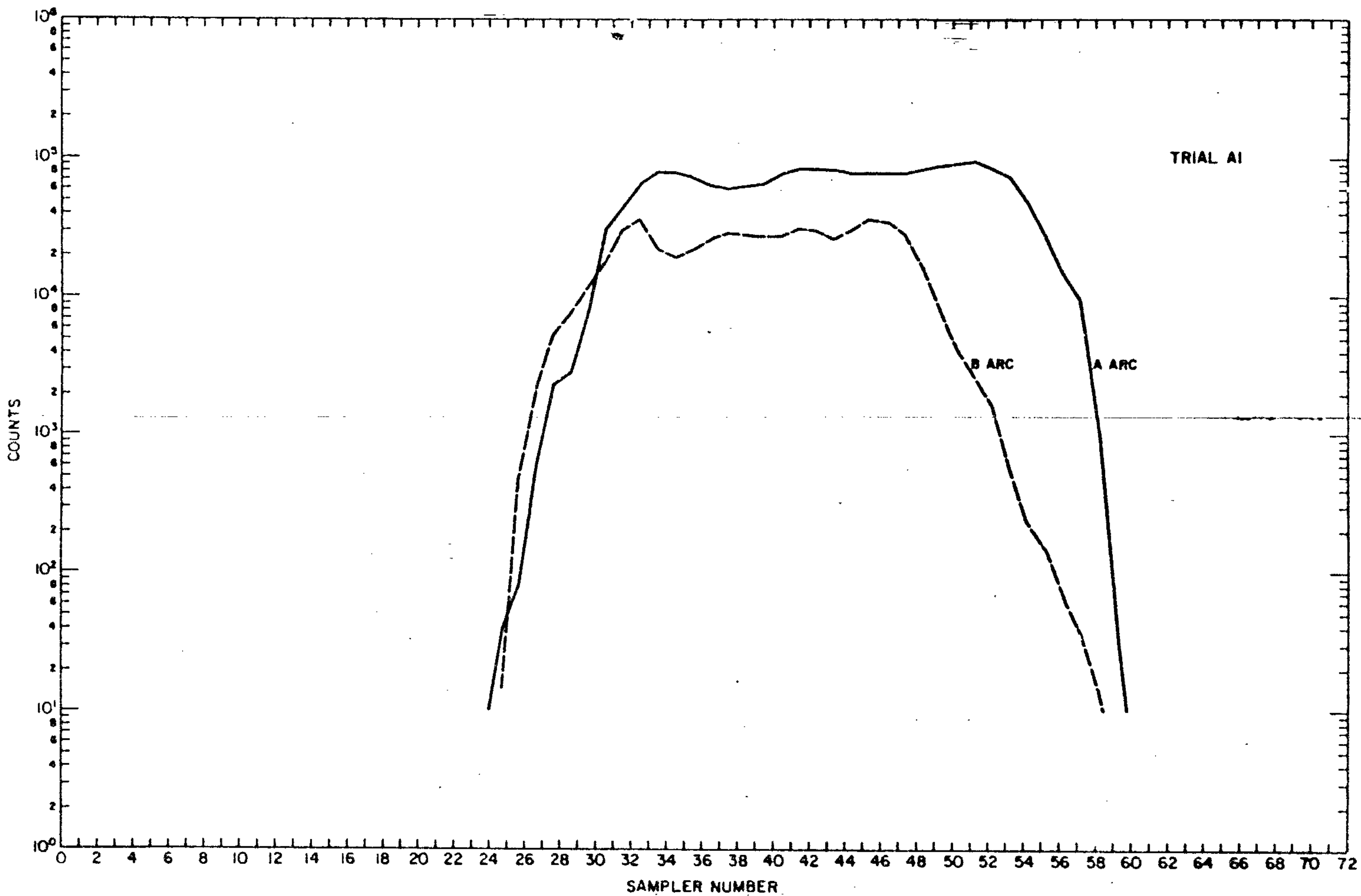


Figure III-1. Smoothed crosswind count profile for Trial A-1.

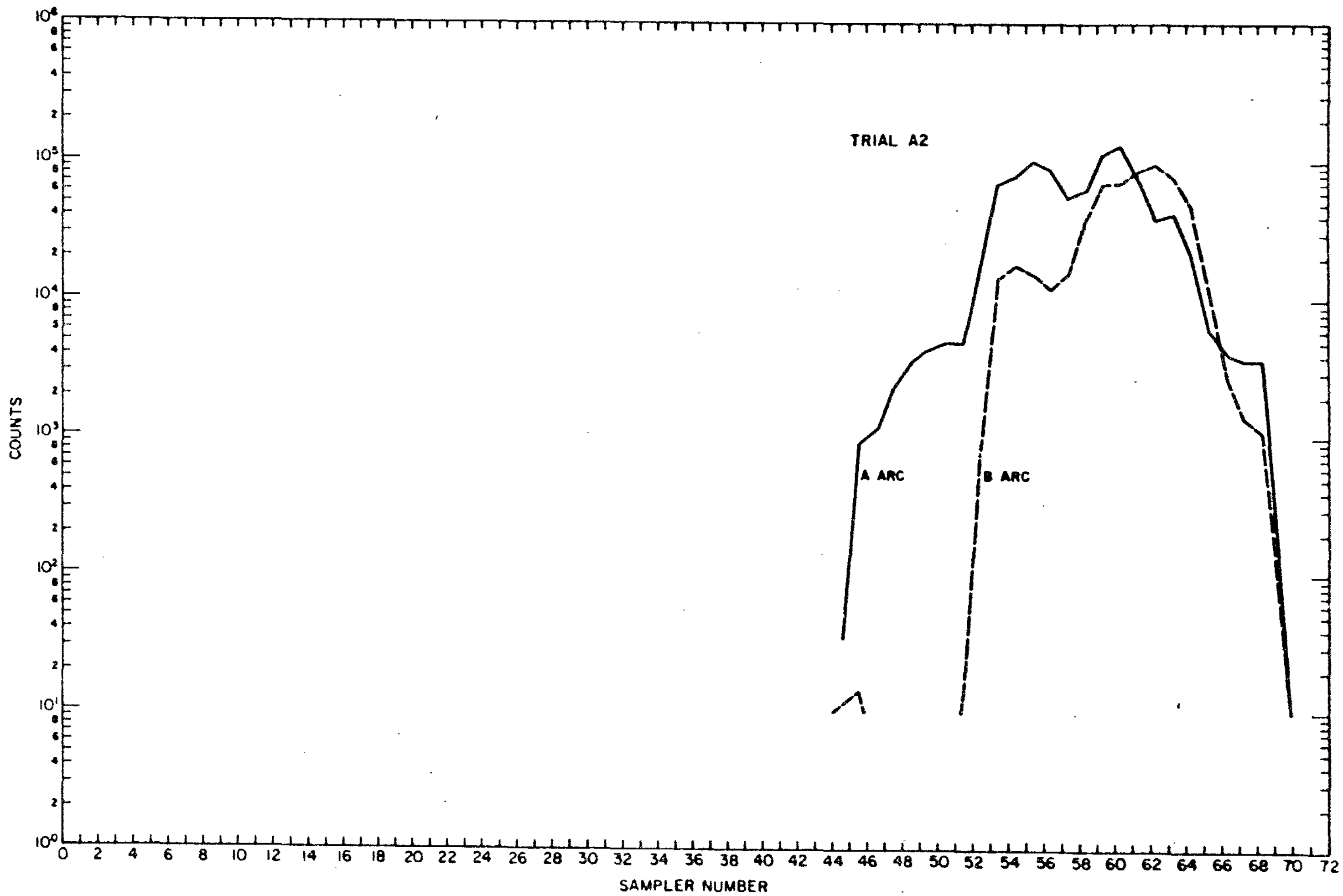


Figure III-2. Smoothed Crosswind Count Profile for Trial A-2.

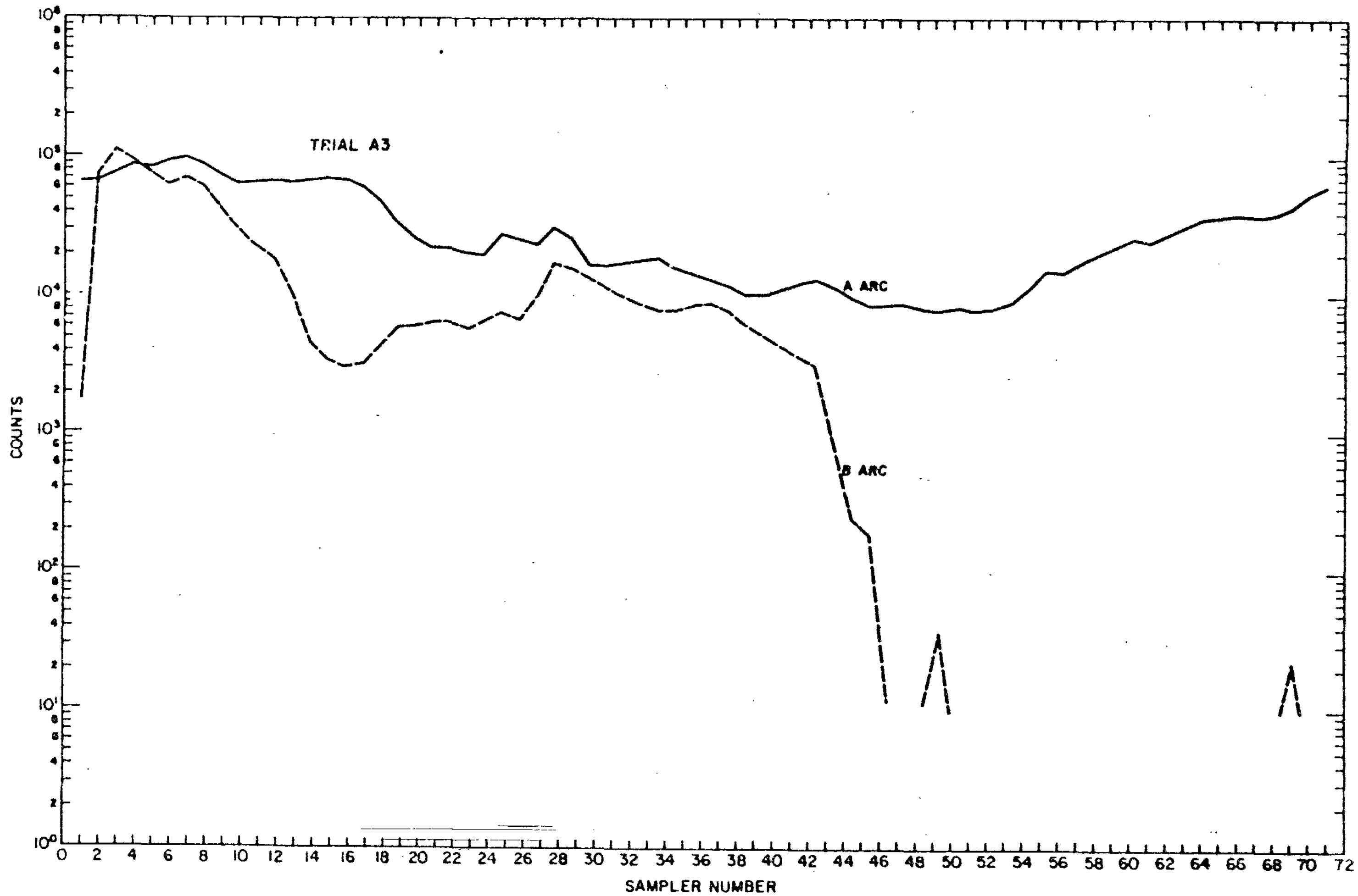


Figure III-3. Smoothed Crosswind Count Profile for Trial A-3.

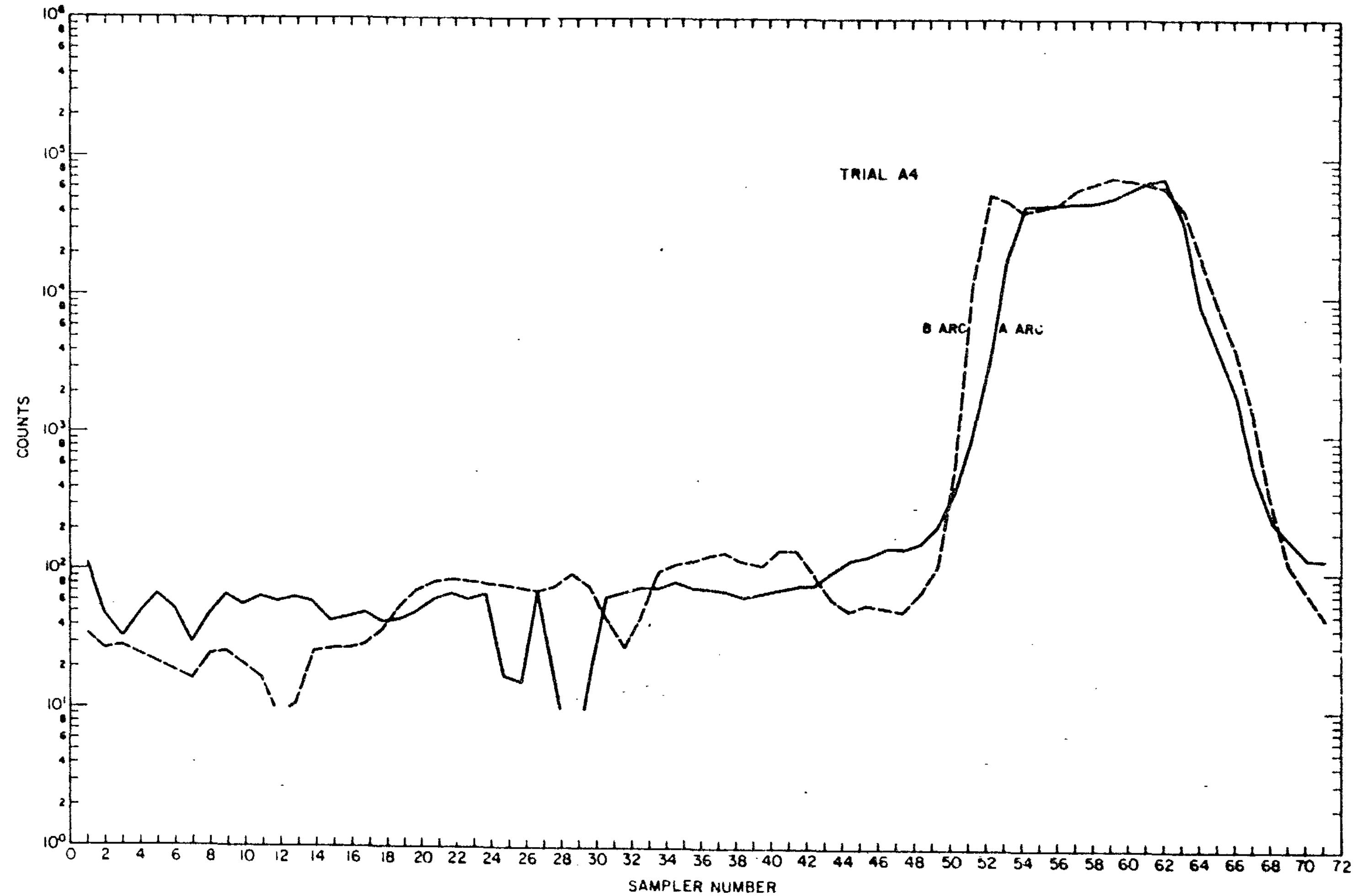


Figure III-4. Smoothed Crosswind Count Profile for Trial A-4.

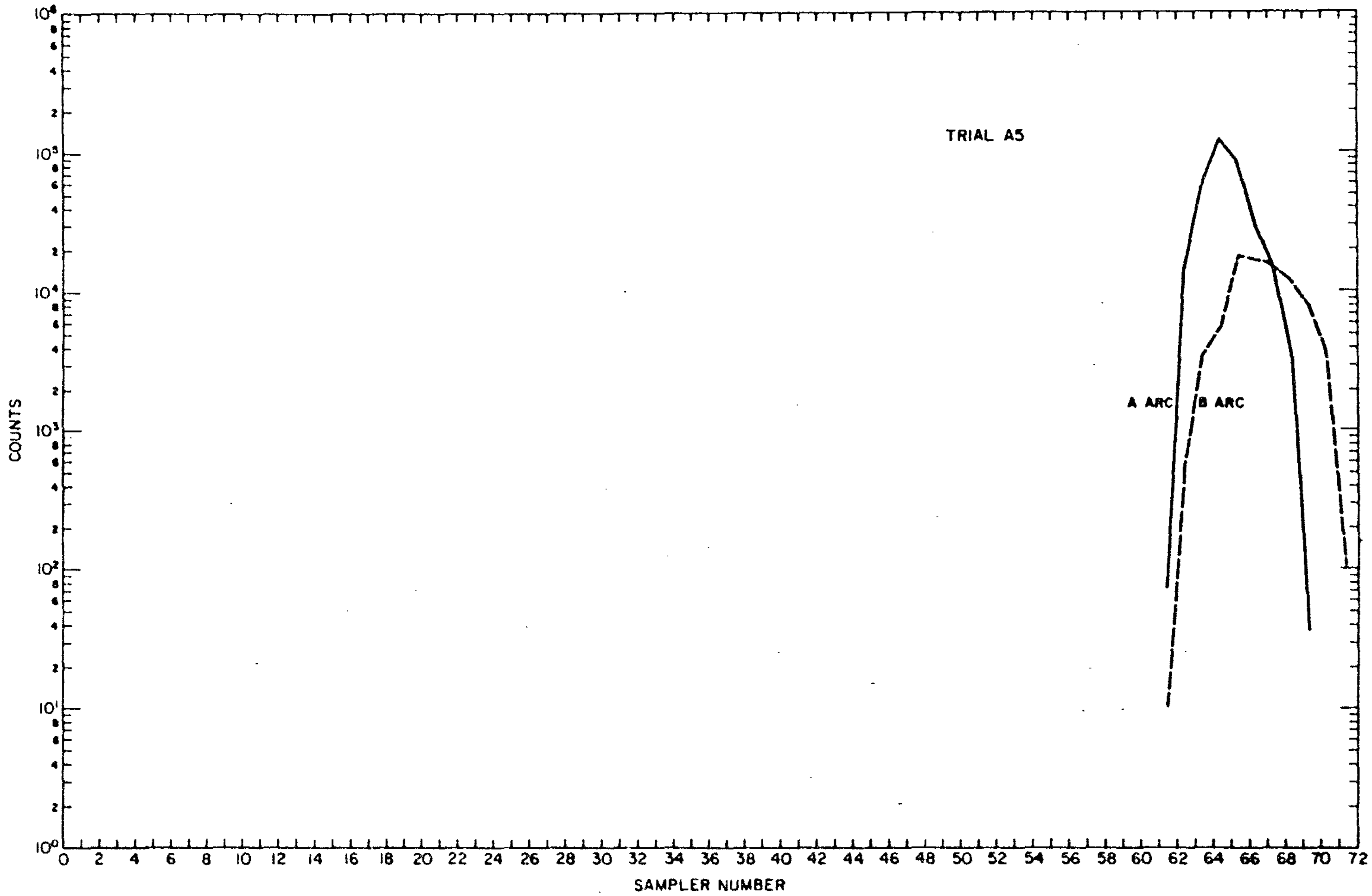


Figure III-5. Smoothed Crosswind Count Profile for Trial A-5.

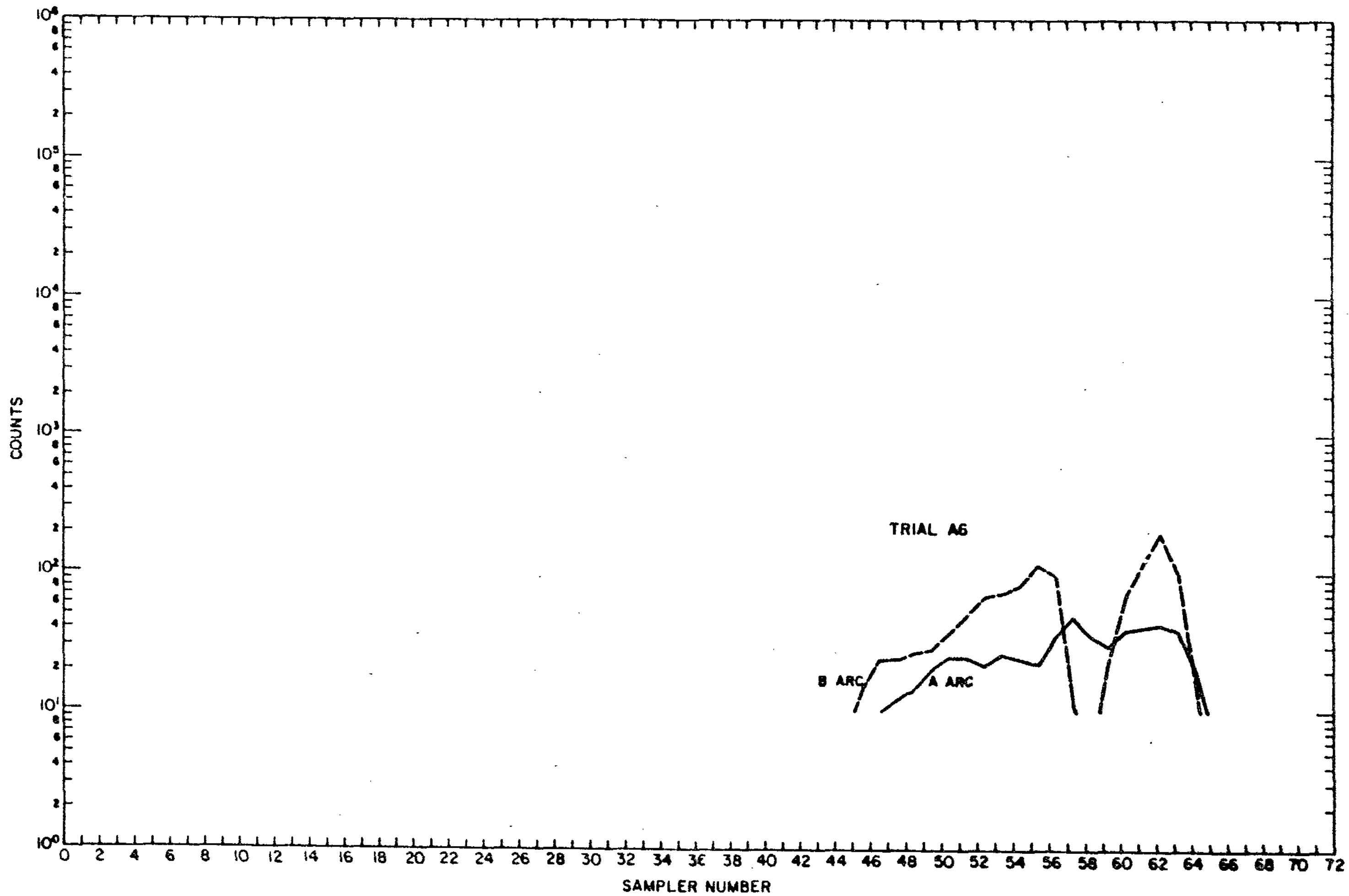


Figure III-6. Smoothed Crosswind Count Profile for Trial A-6.

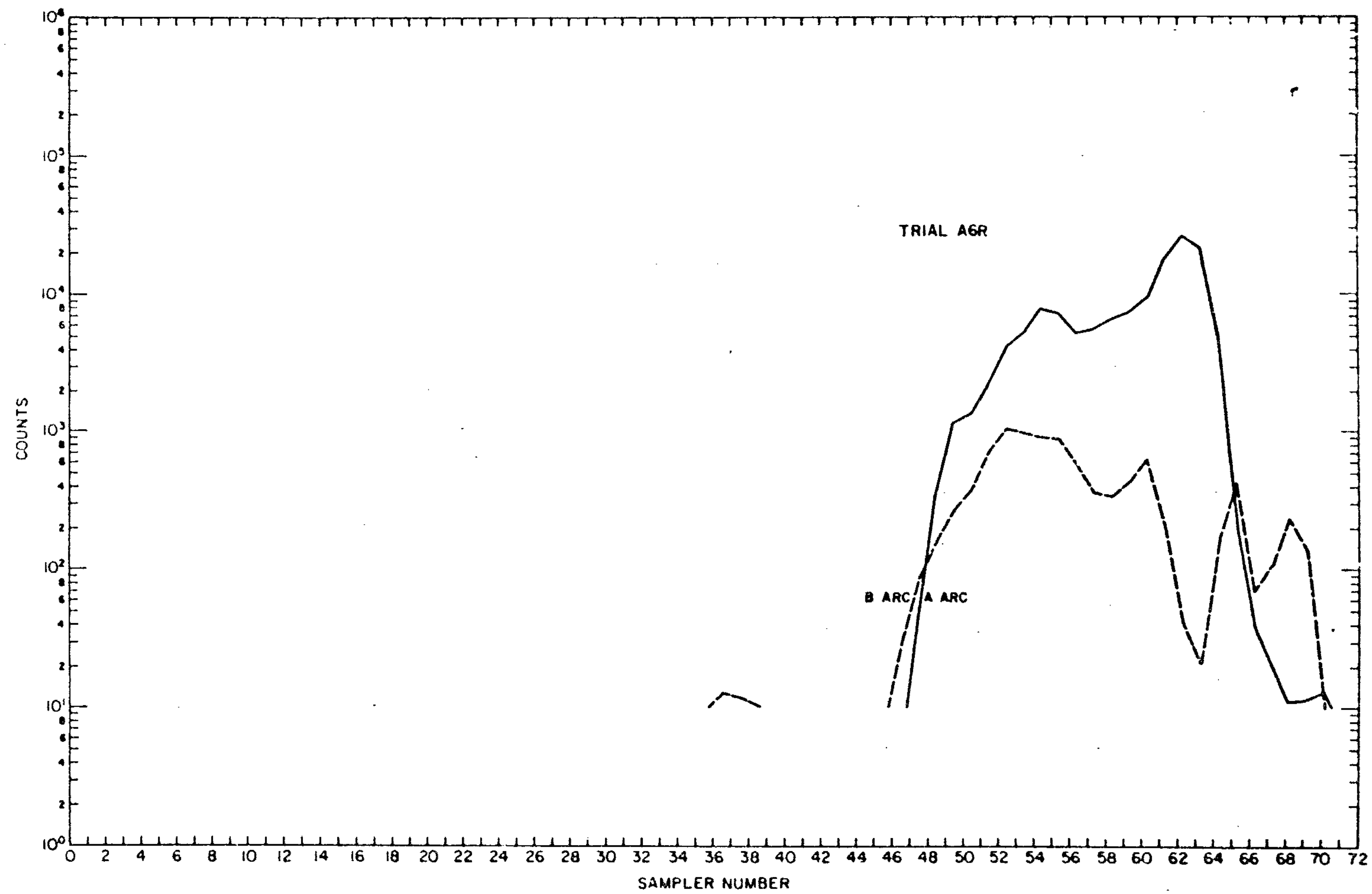


Figure III-7. Smoothed Crosswind Count Profile for Trial A-6R.

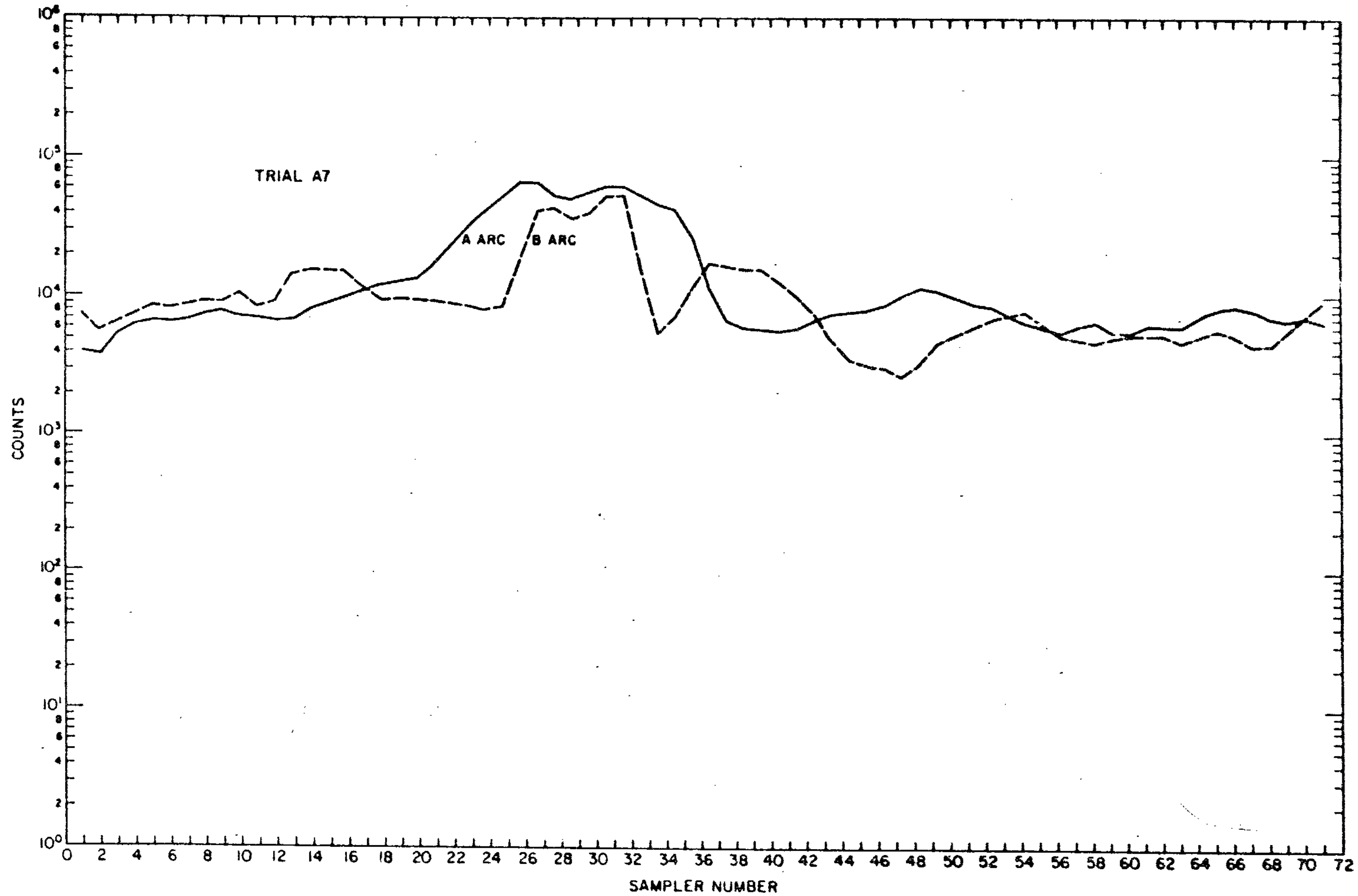


Figure III-8. Smoothed Crosswind Count Profile for Trial A-7.

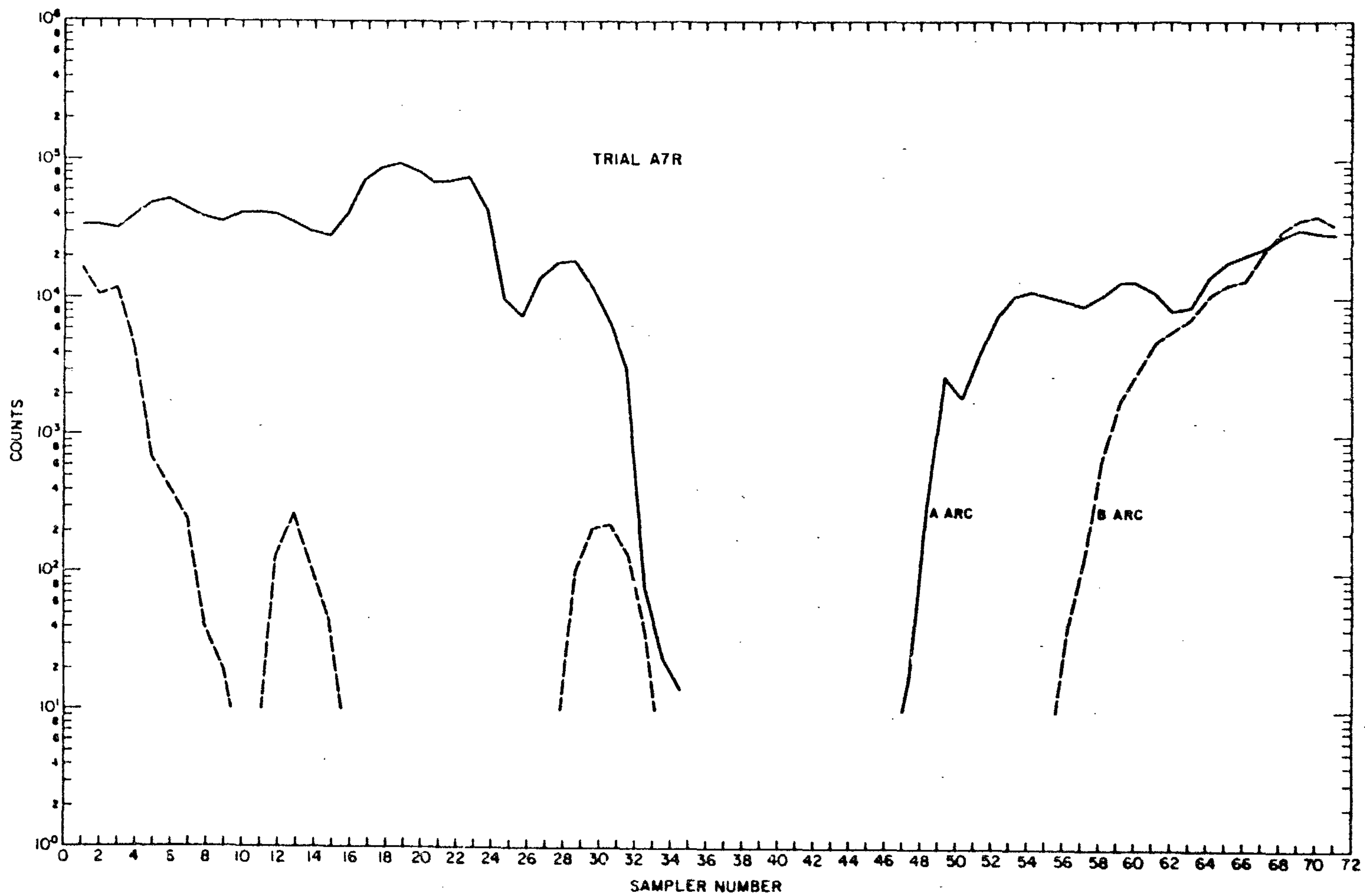


Figure III-9. Smoothed Crosswind Count Profile for Trial A-7R.

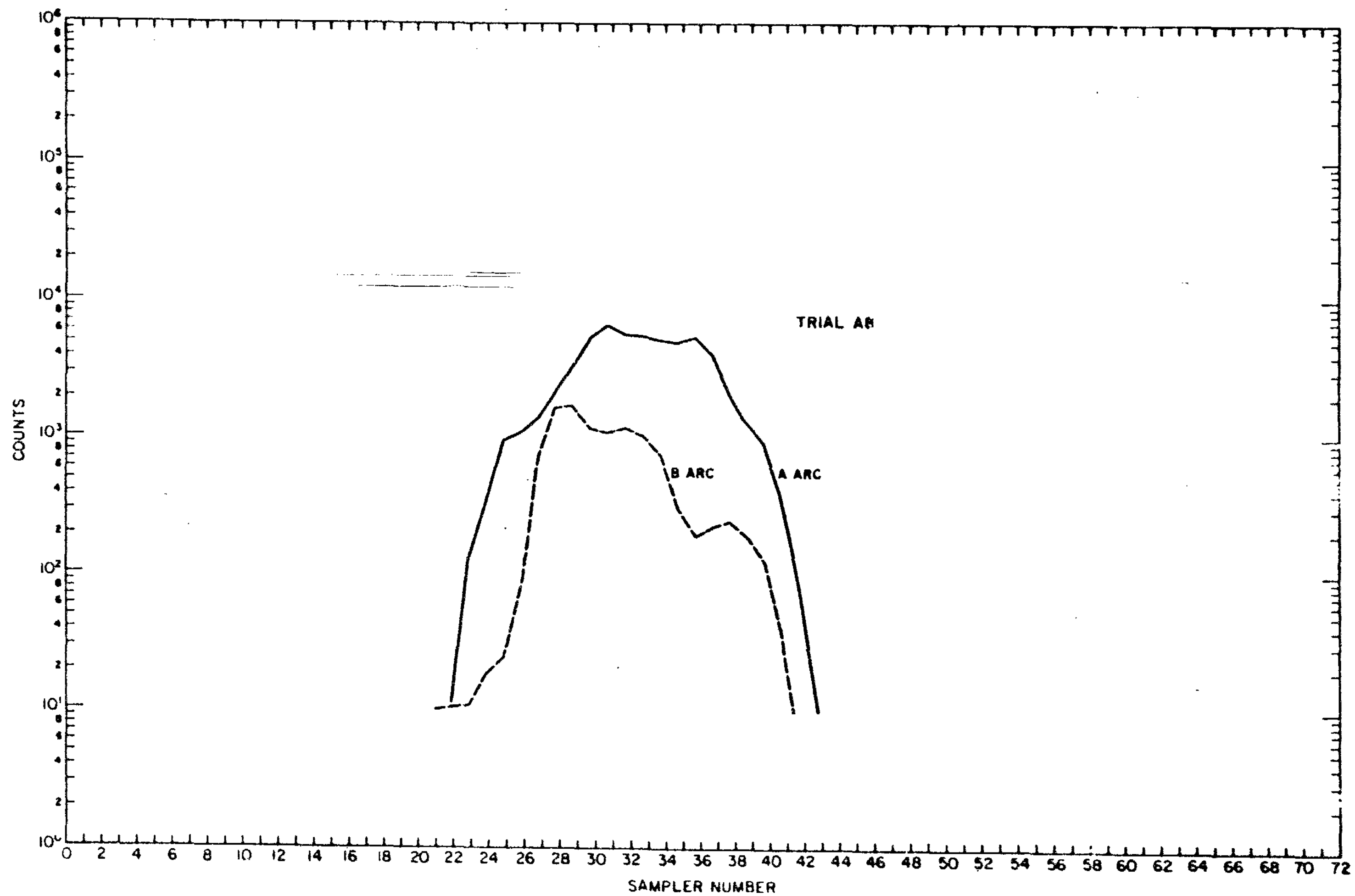


Figure III-10. Smoothed Crosswind Count Profile for Trail A-8.

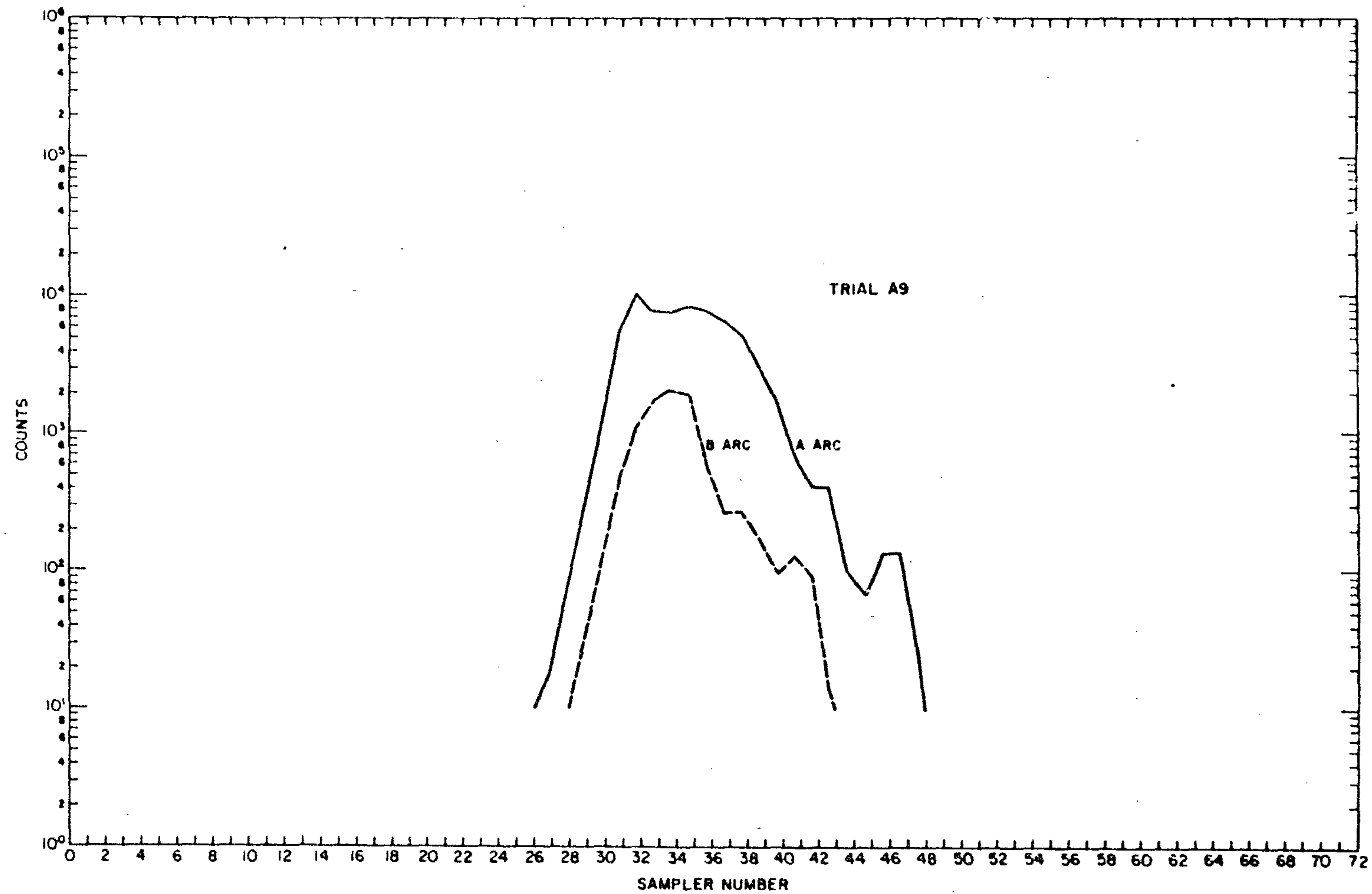


Figure III-11. Smoothed Crosswind Count Profile for Trial A-9.

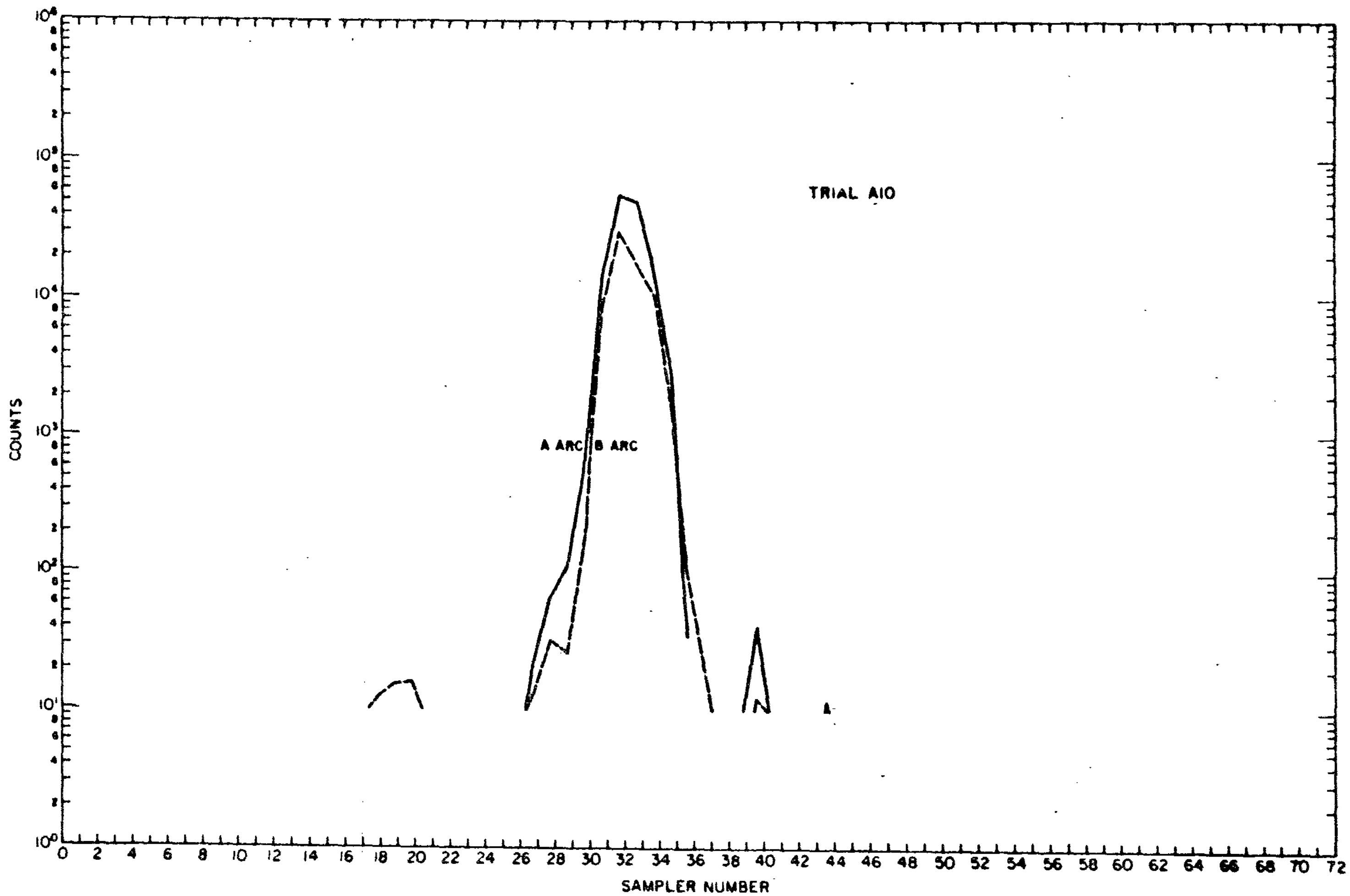


Figure III-12. Smoothed Crosswind Count Profile for Trial A-10.

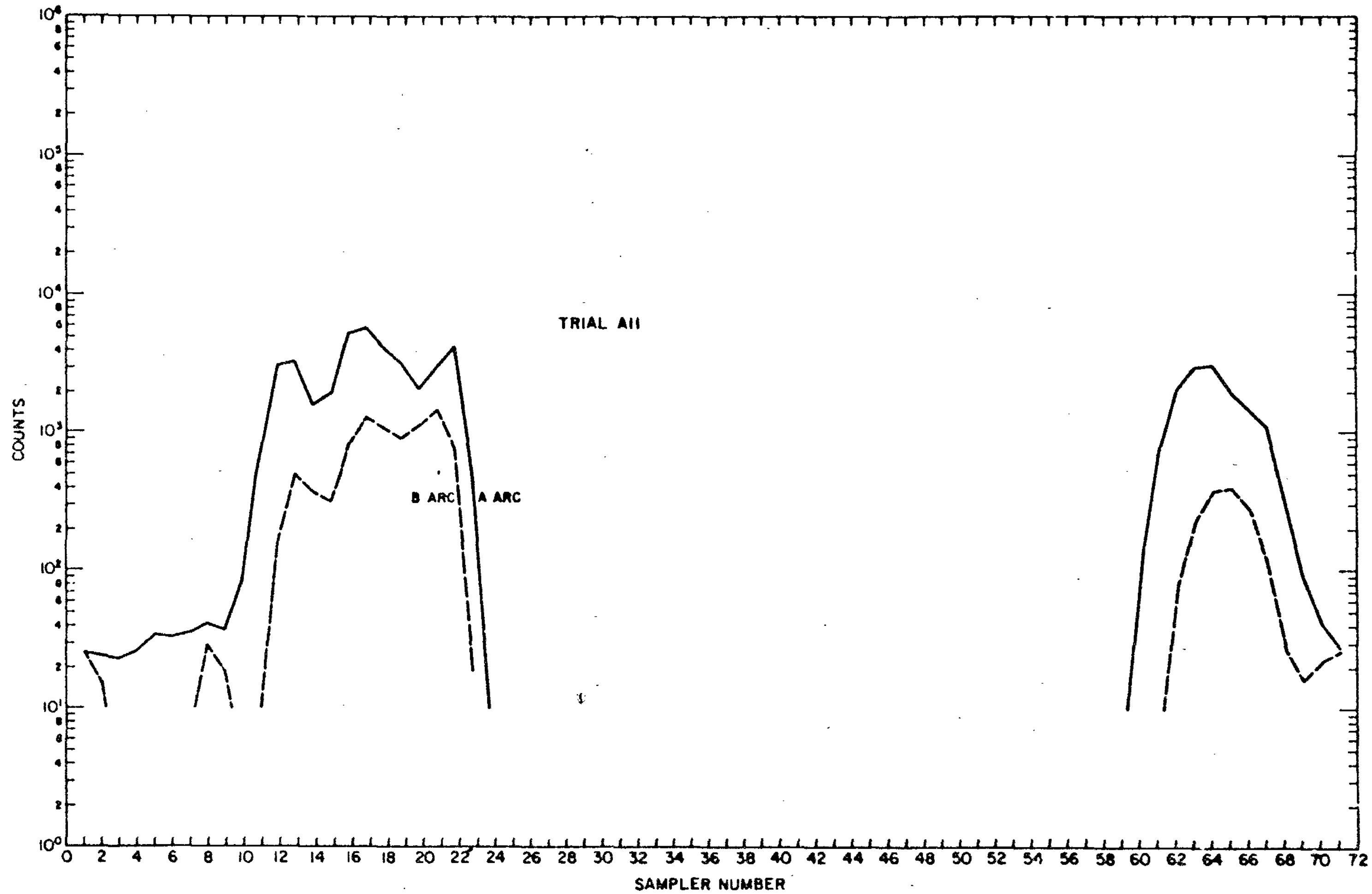


Figure III-13. Smoothed Crosswind Count Profile for Trial A-11.

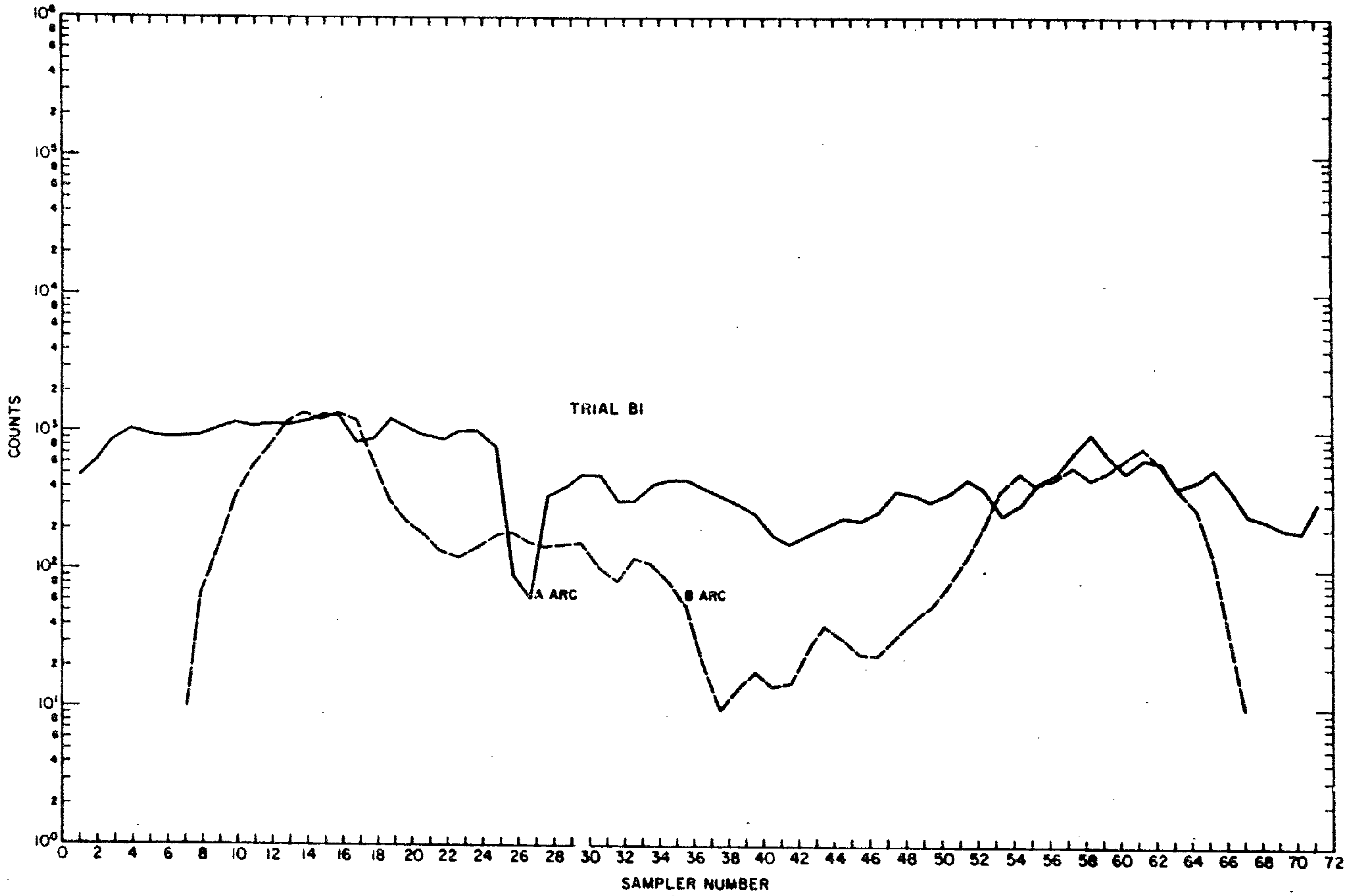


Figure III-14. Smoothed Crosswind Count Profile for Trial B-1.

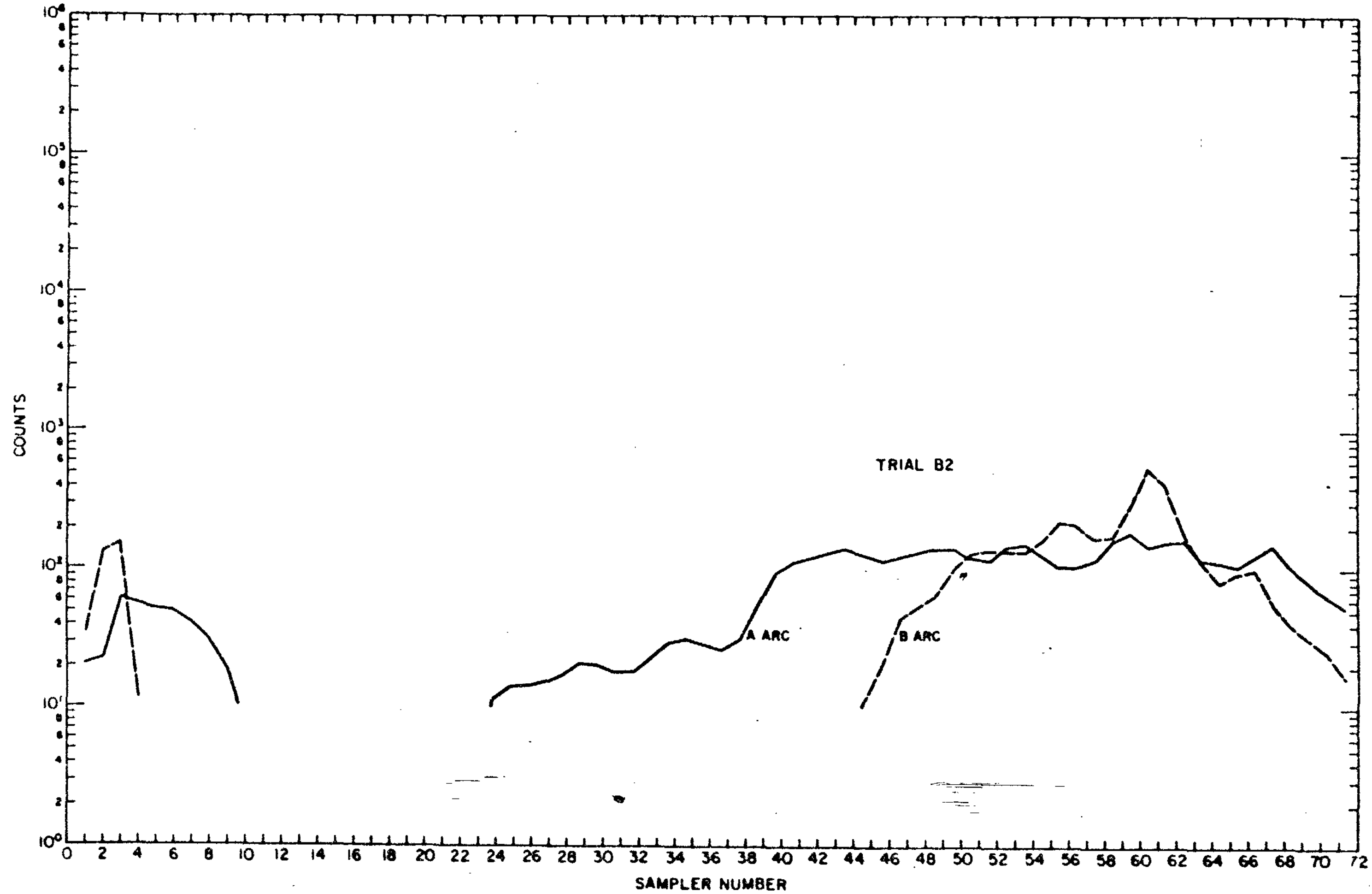


Figure III-15. Smoothed Crosswind Count Profile for Trial B-2.

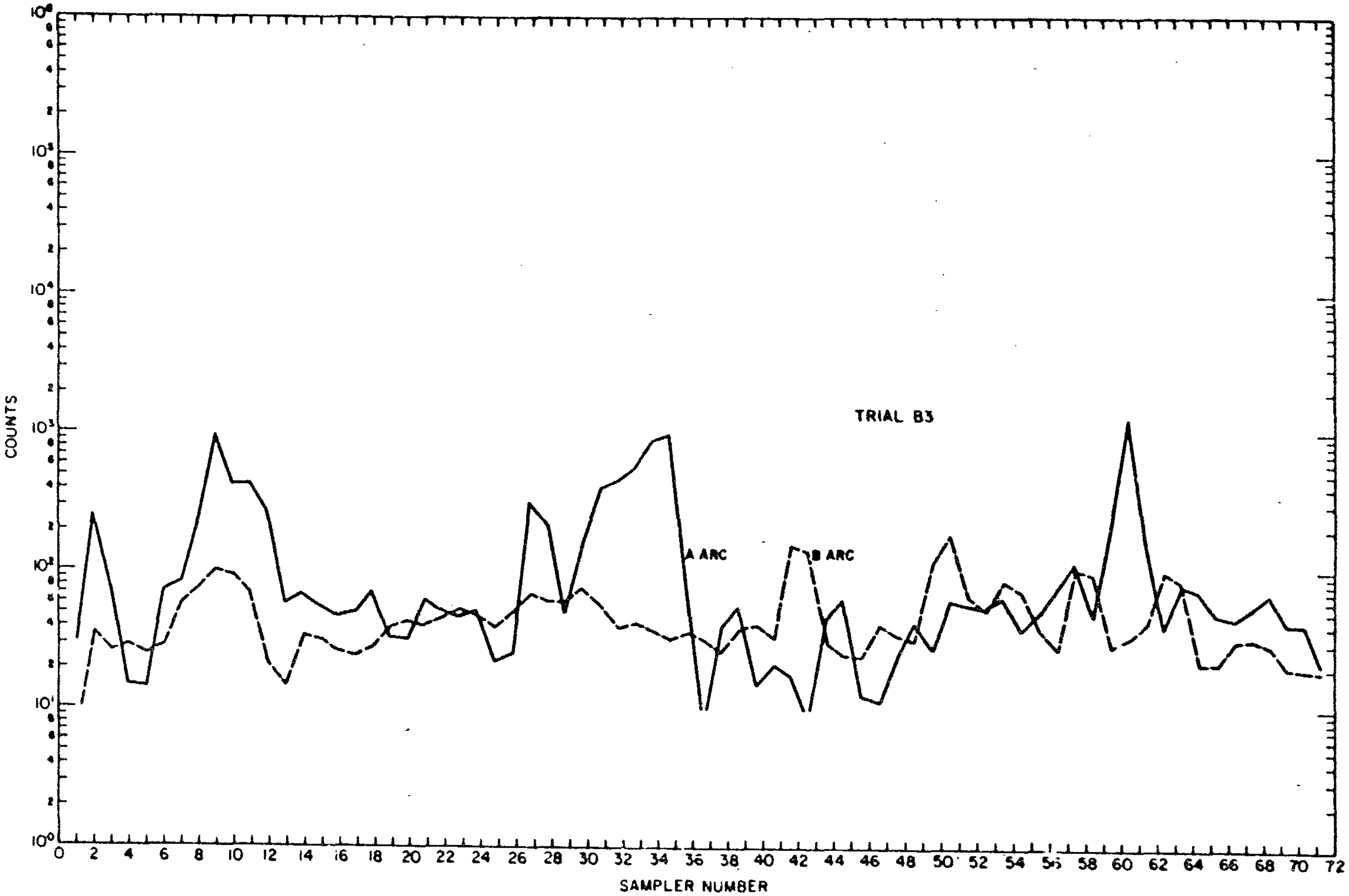


Figure III-16. Smoothed Crosswind Count Profile for Trial B-3.

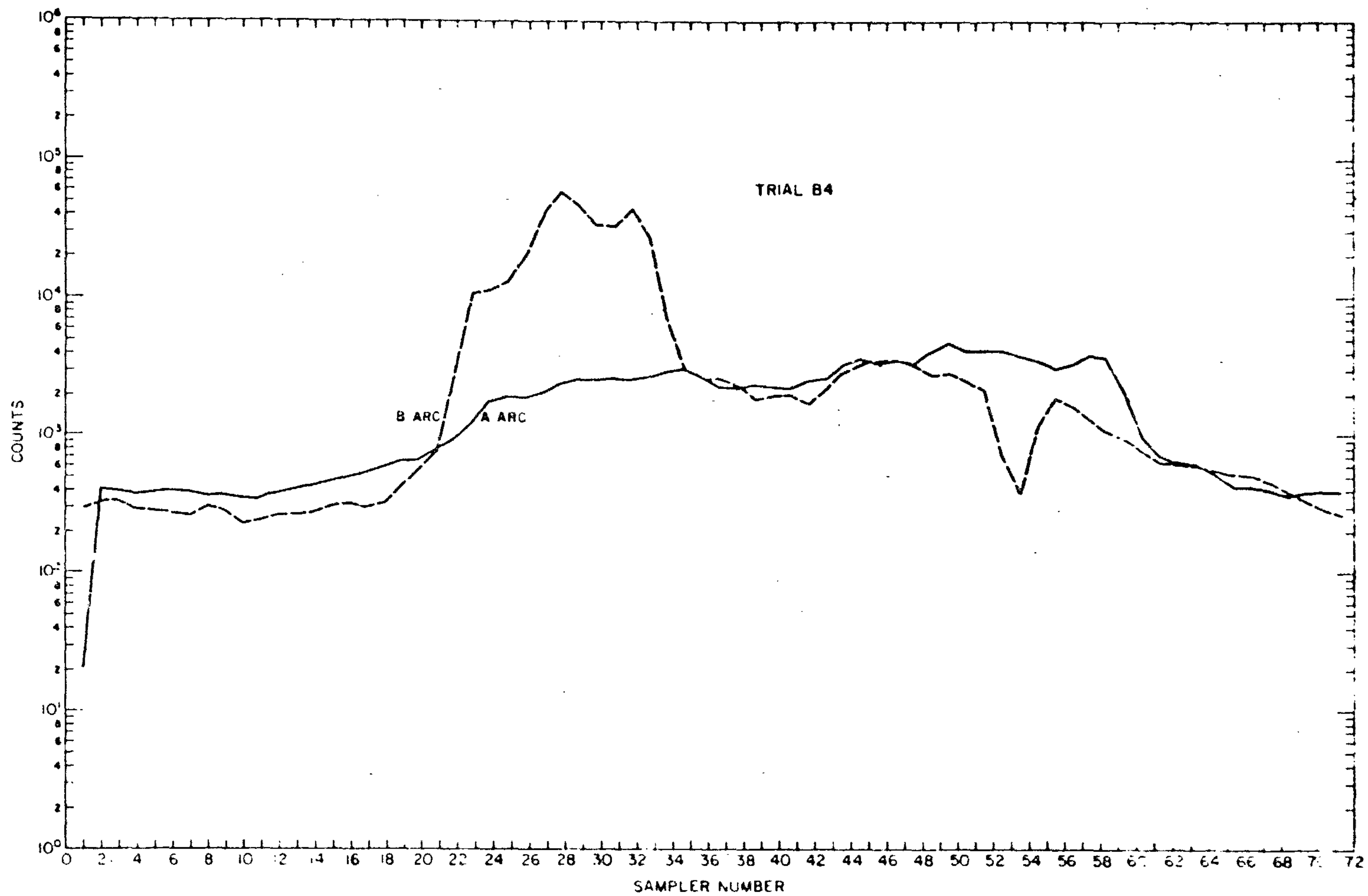


Figure III-17. Smoothed Crosswind Count Profile for Trial B-4.

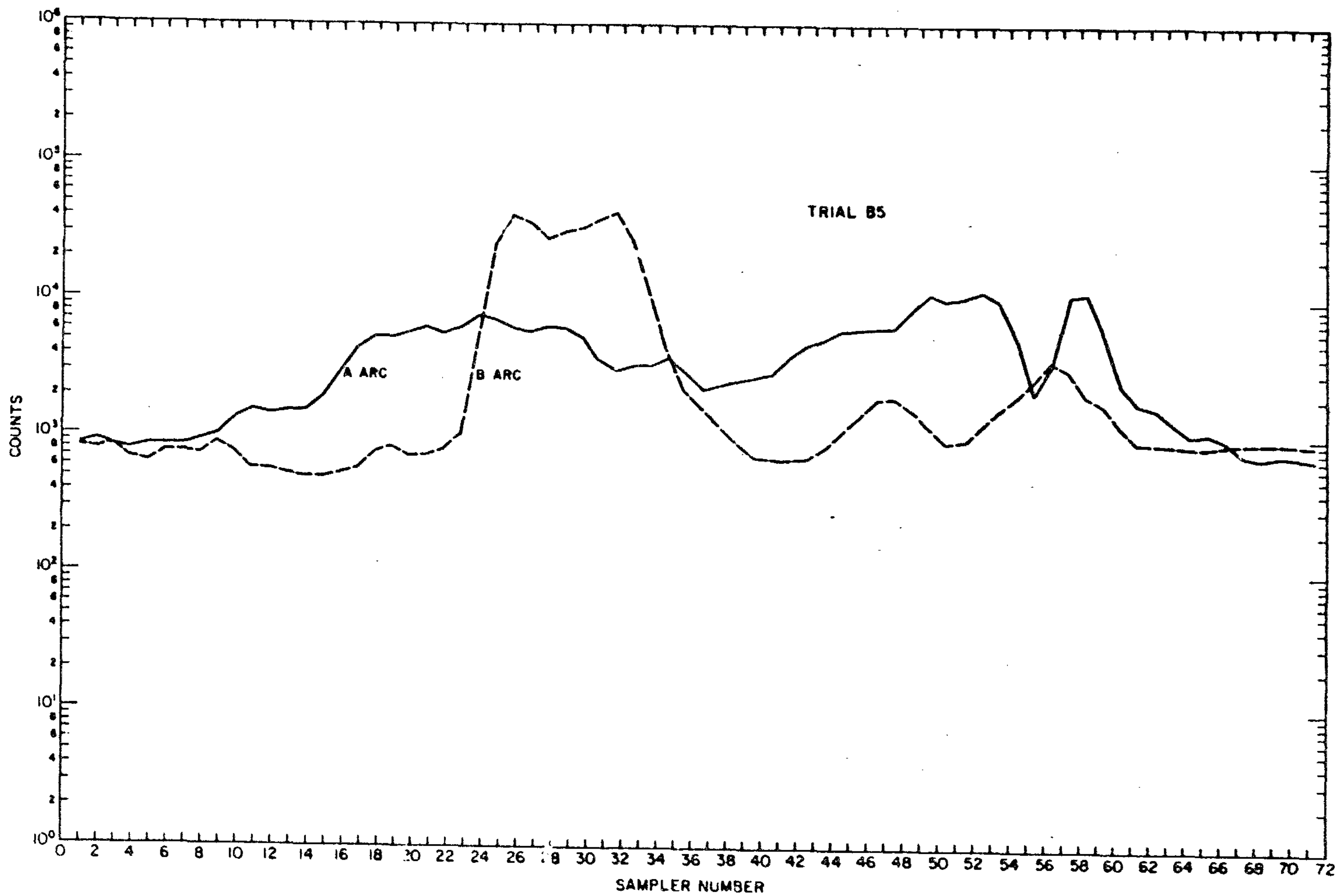


Figure III-18. Smoothed Crosswind Count Profile for Trial B-5.

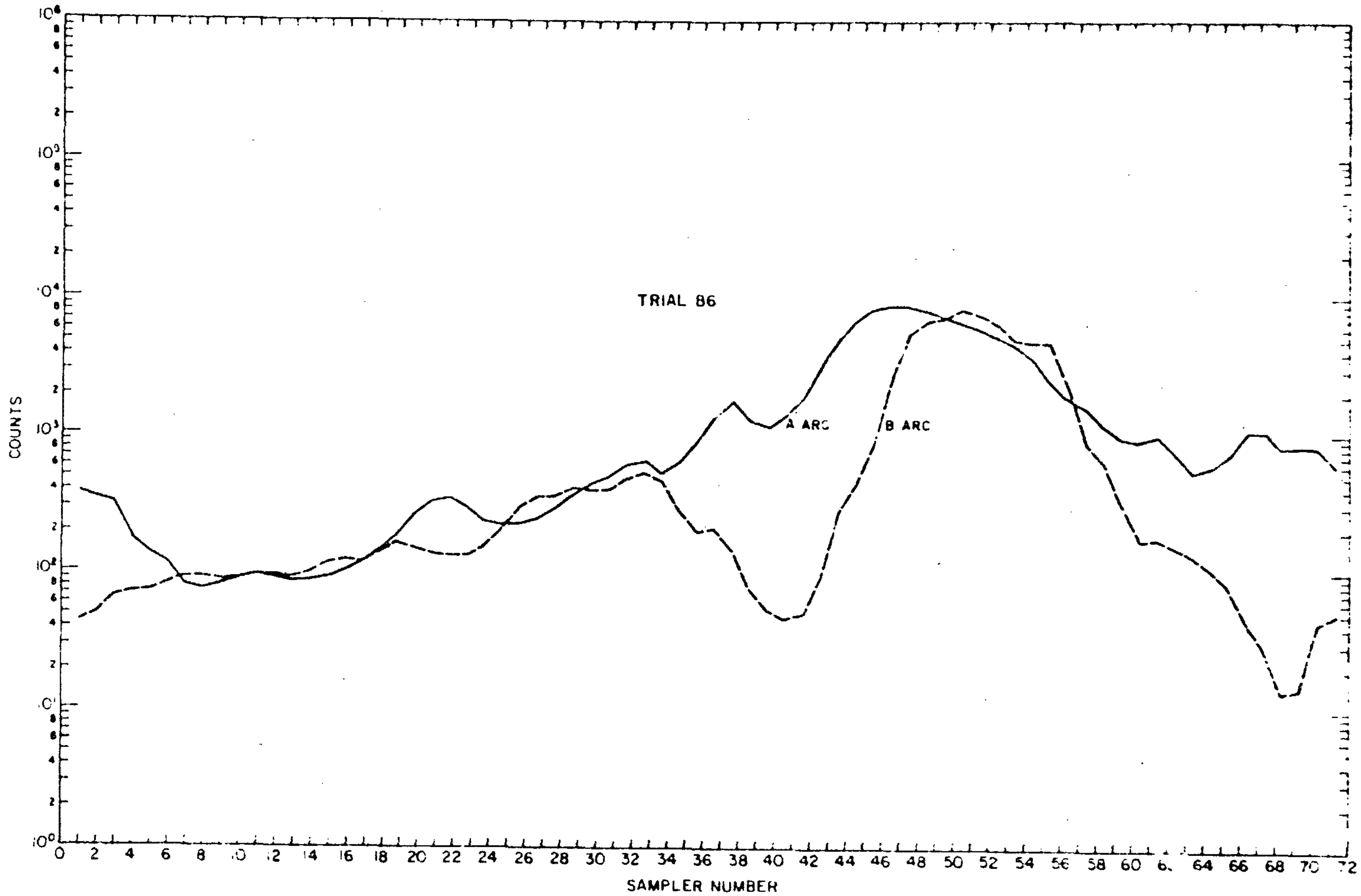


Figure III-19. Smoothed Crosswind Count Profile for Trial B-6.

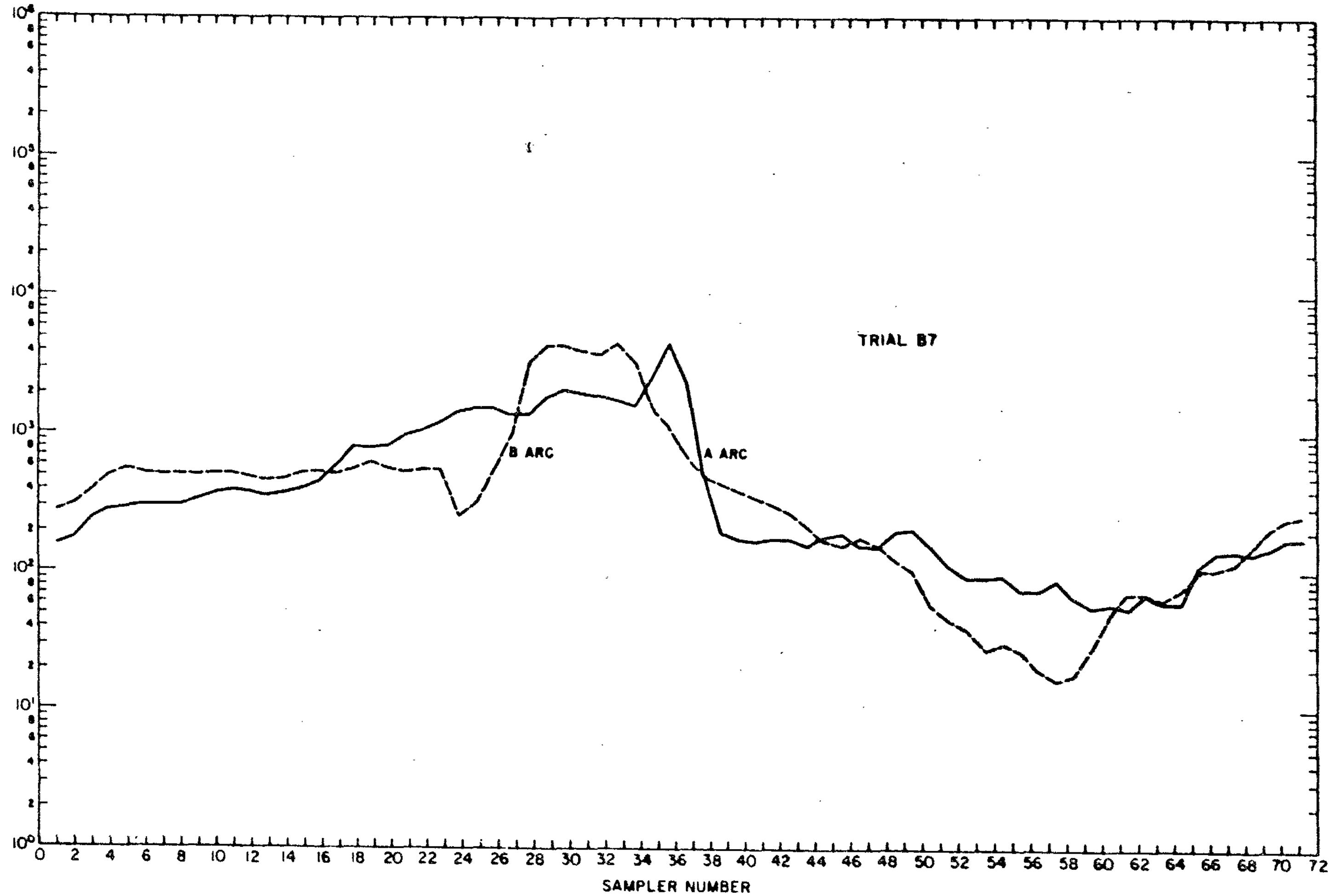


Figure III-20. Smoothed Crosswind Count Profile for Trial B-7.

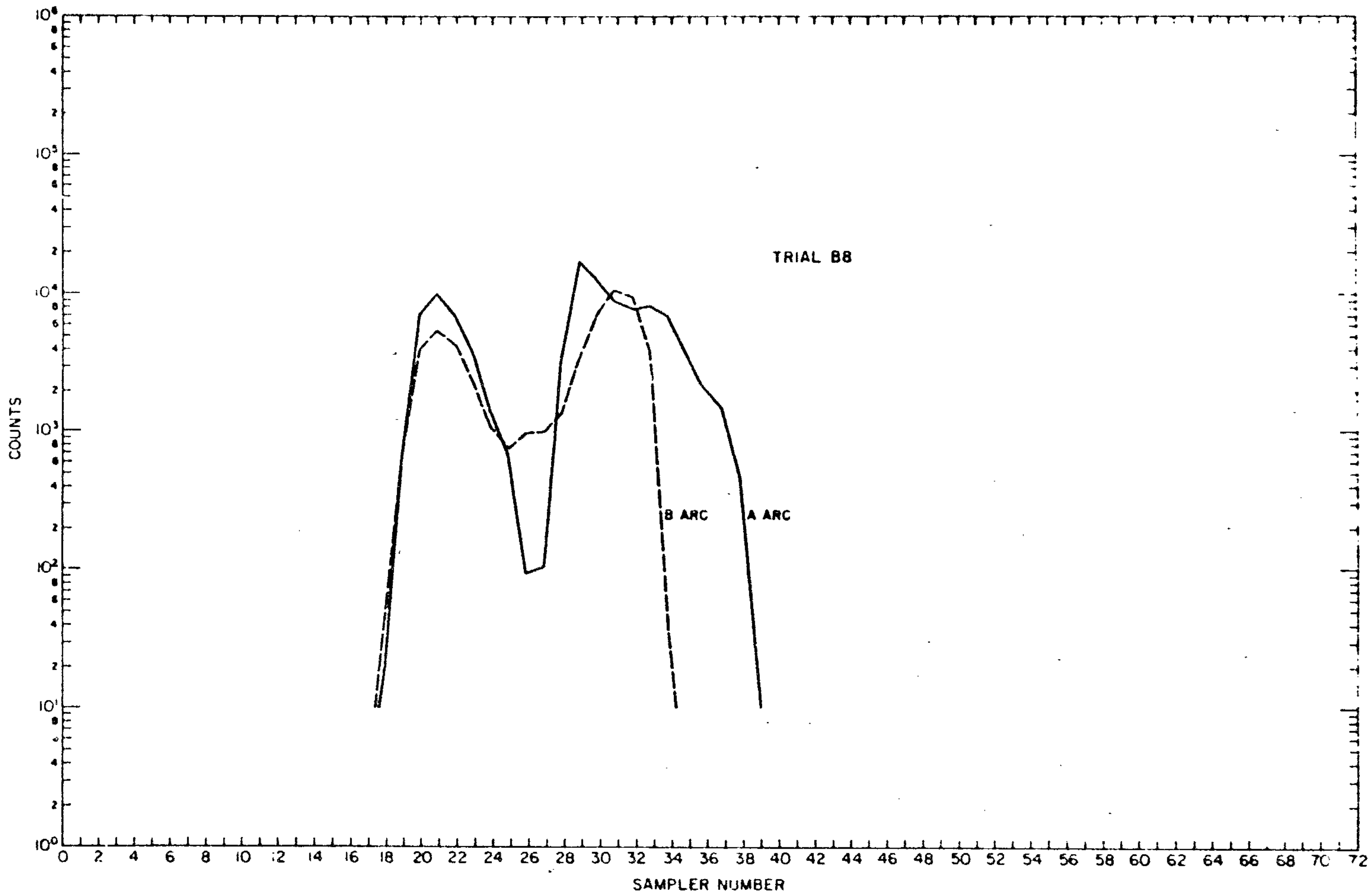


Figure III-21. Smoothed Crosswind Count Profile for Trial B-8.

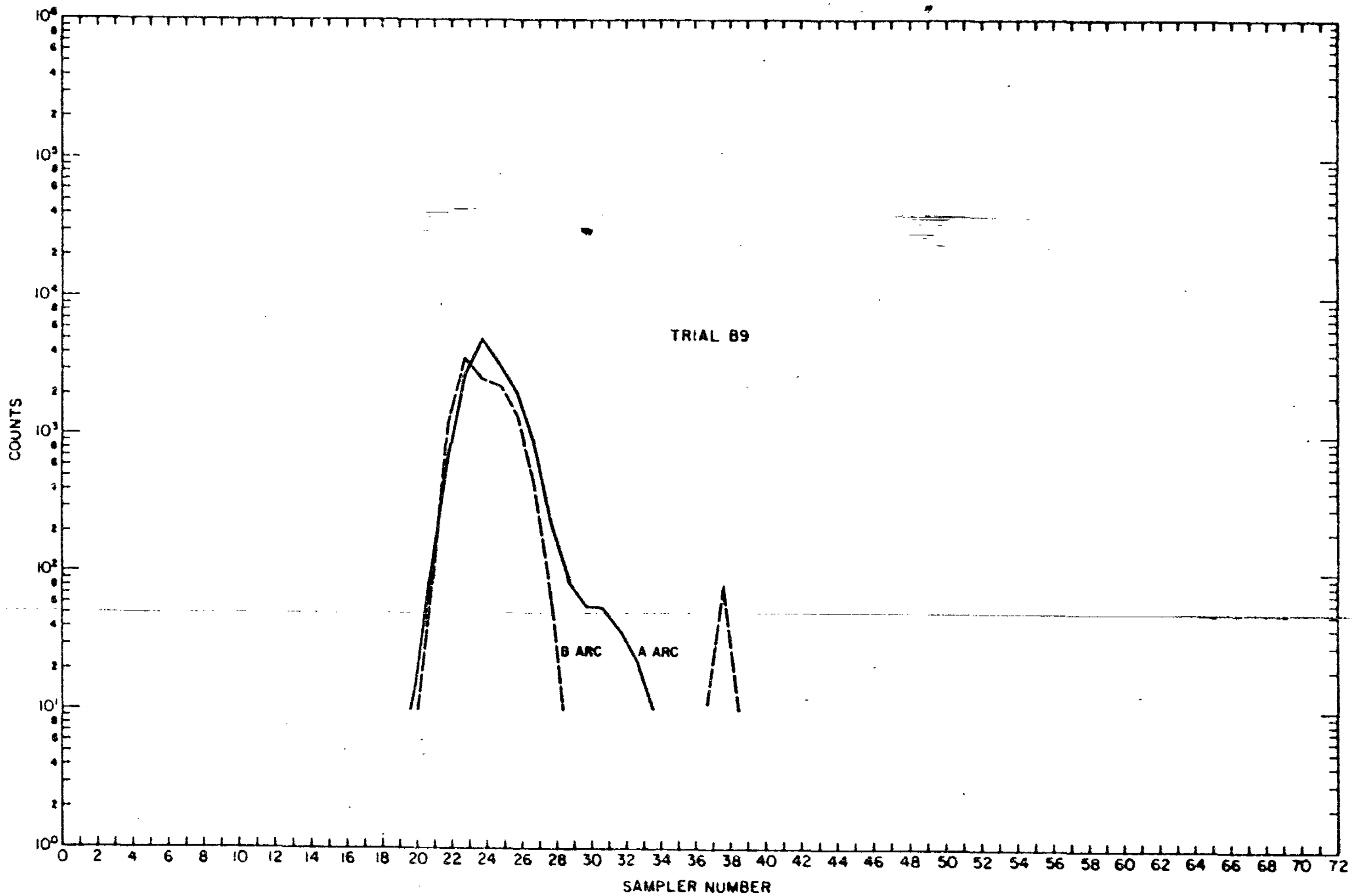


Figure III-22. Smoothed Crosswind Count Profile for Trial B-9.

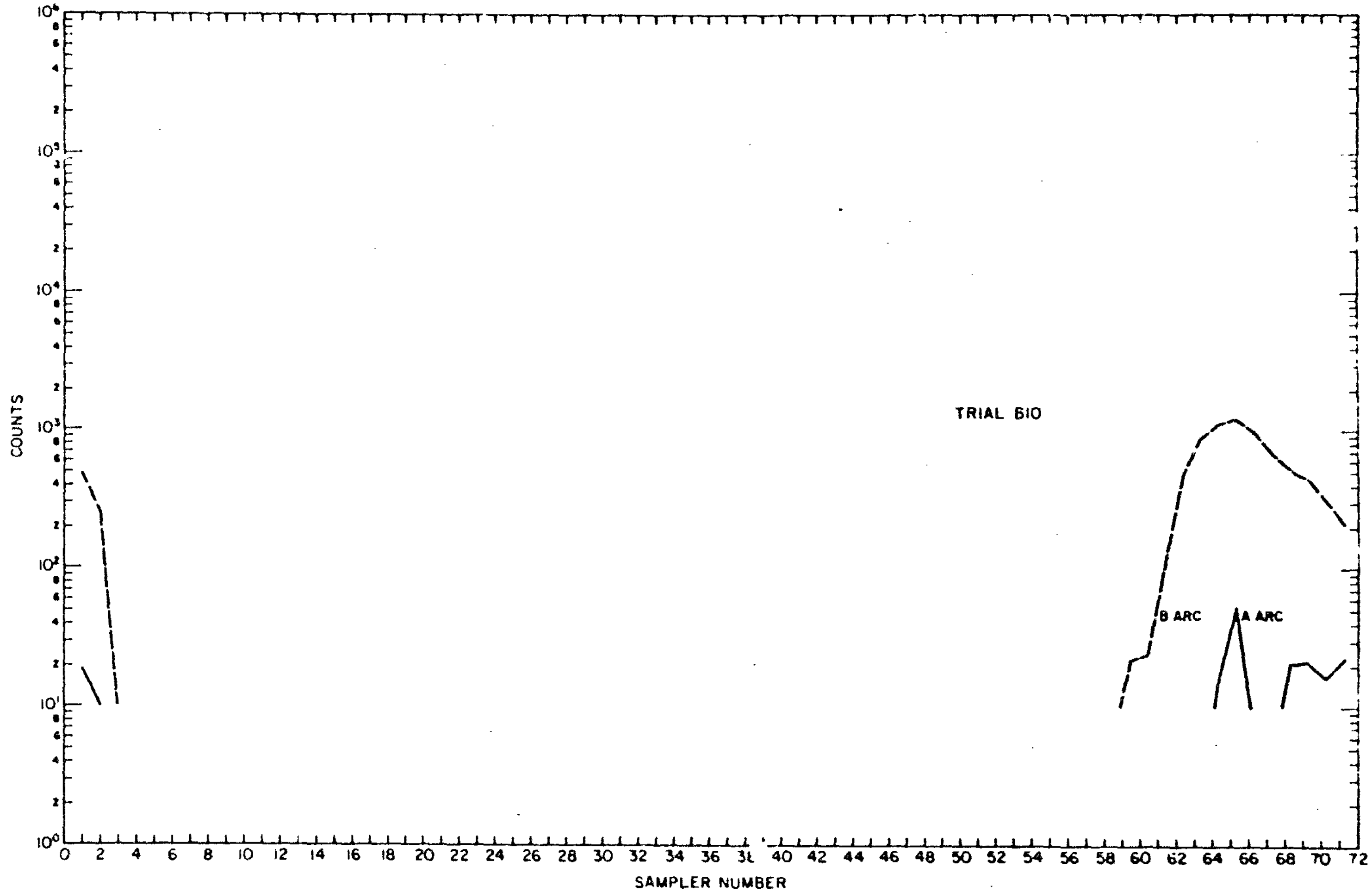


Figure III-23. Smoothed Crosswind Count Profile for Trial B-10.

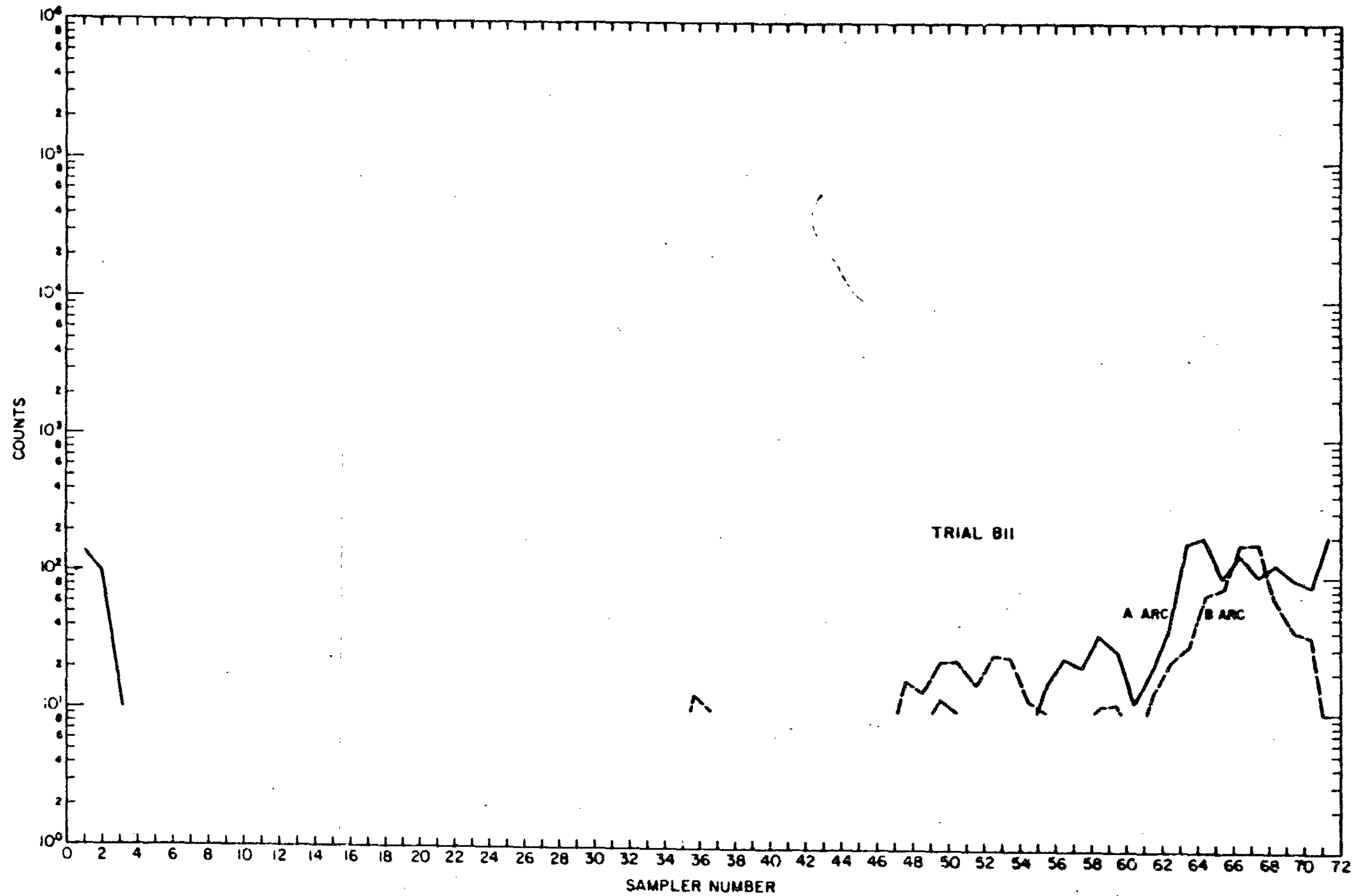


Figure III-24. Smoothed Crosswind Count Profile for Trial B-11.

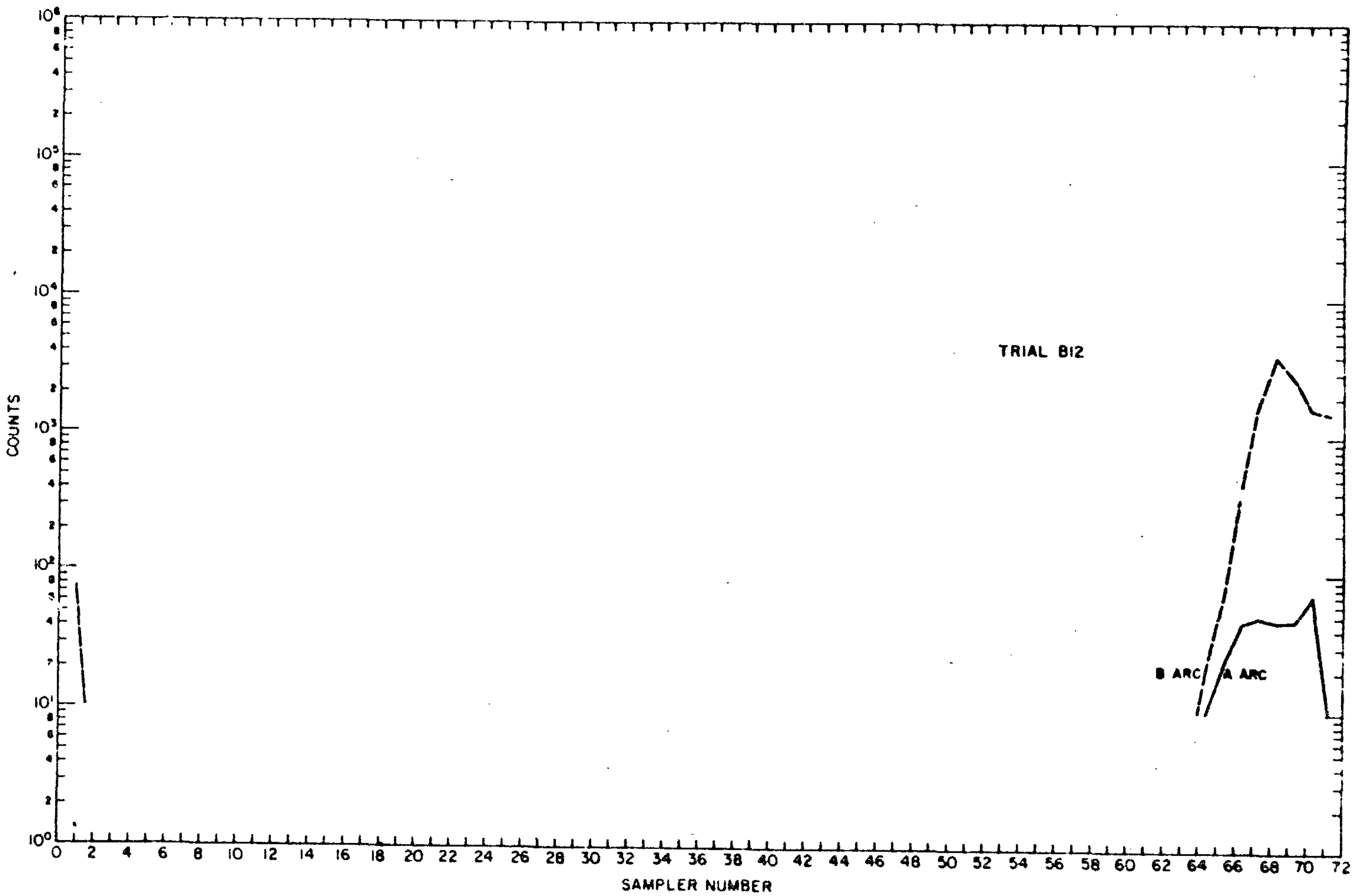


Figure III-25. Smoothed Crosswind Count Profile for Trial B-12.

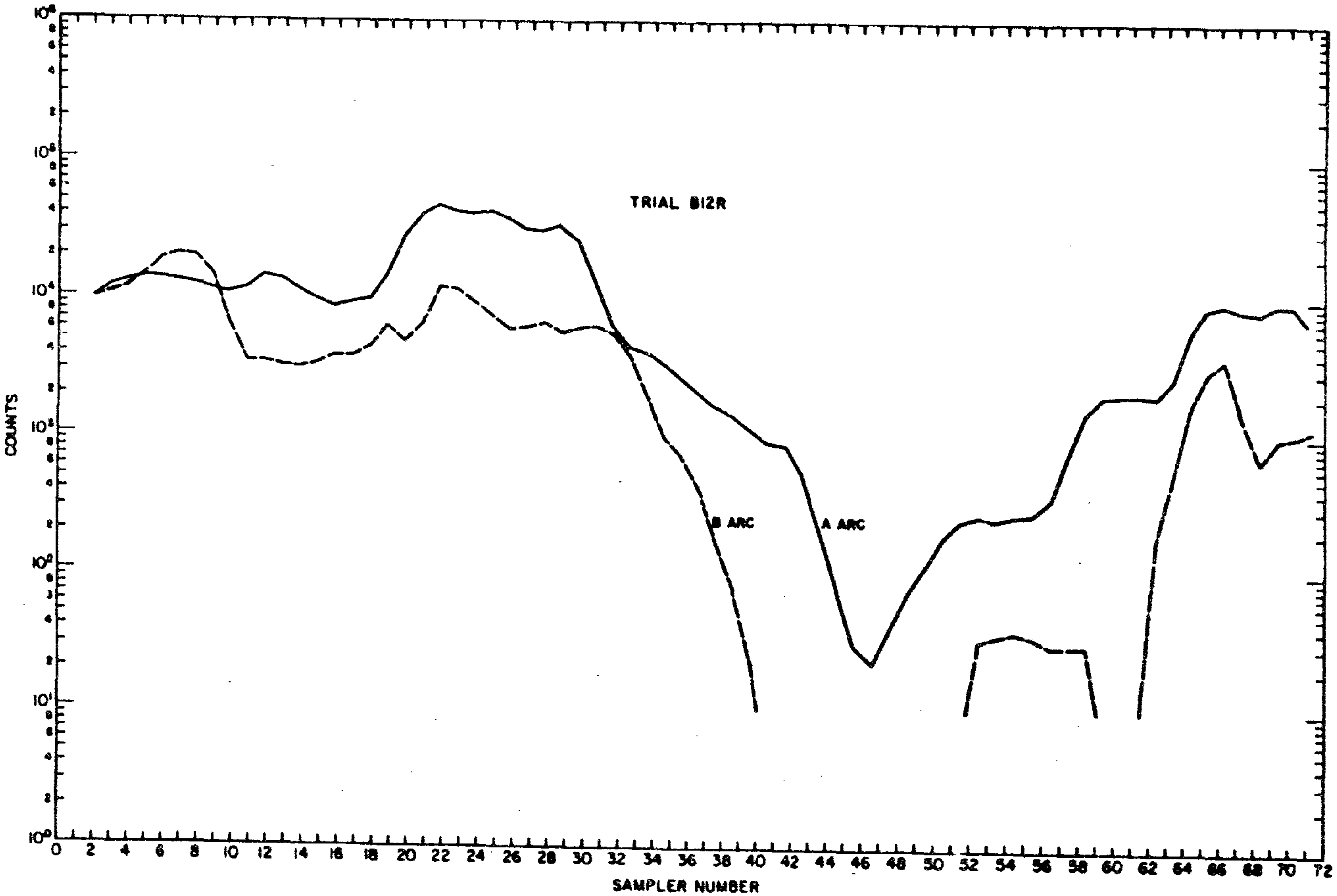
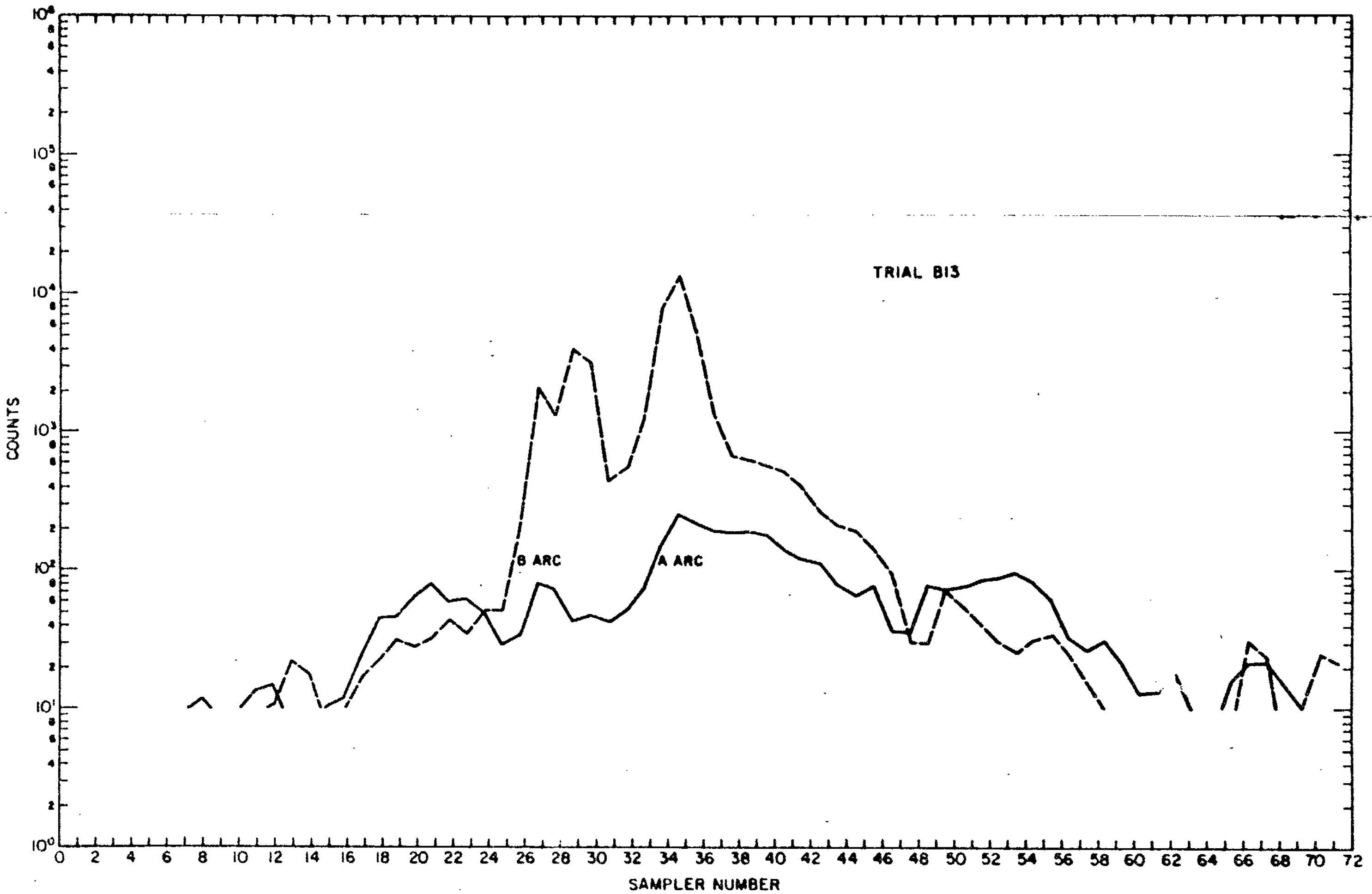


Figure III-26. Smoothed Crosswind Count Profile for Trial B-12R.



Fi_ .re III-27. Smoothed Crosswind Count Profile for Trial B-13.

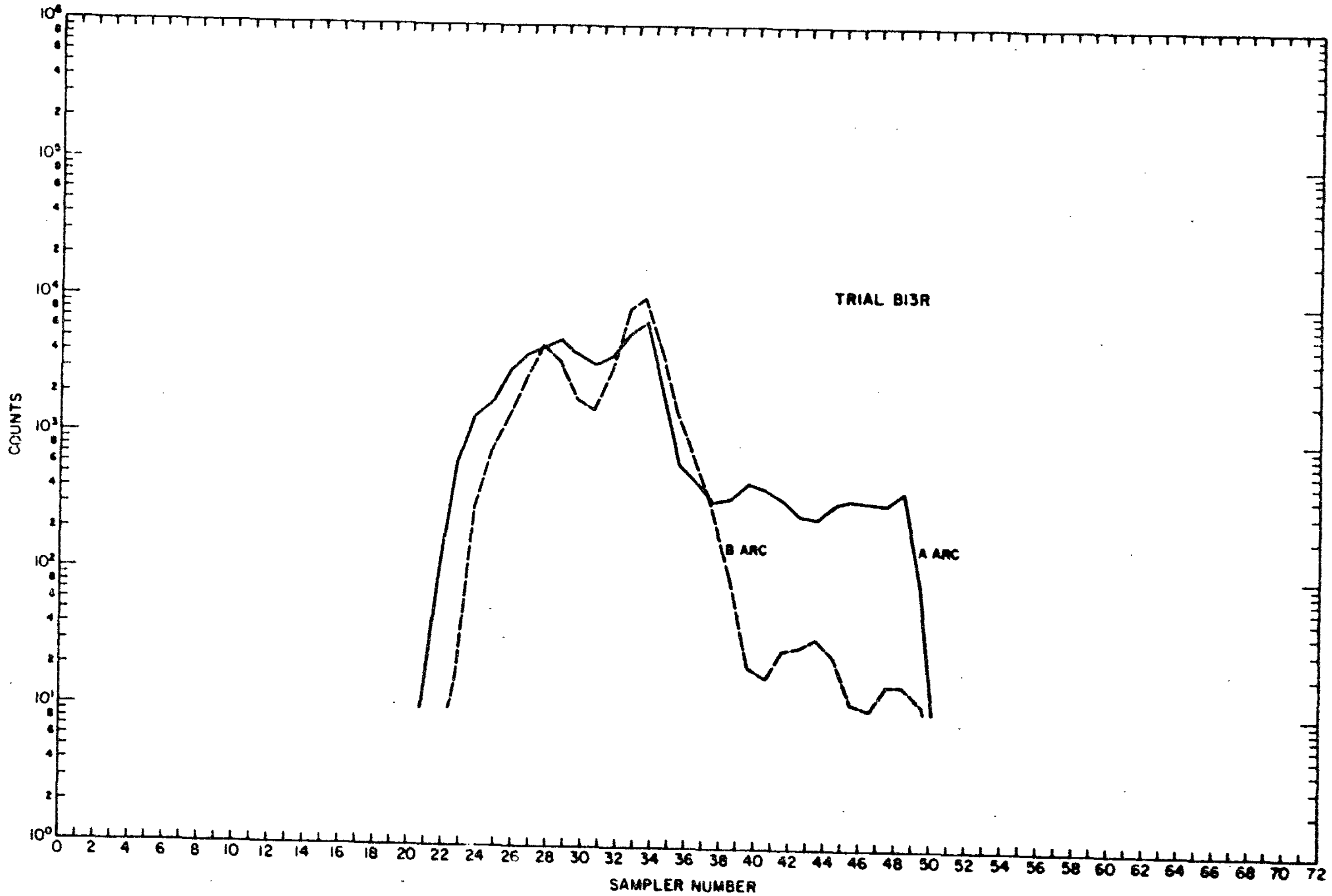


Figure III-28. Smoothed Cro… ind Count Profile for Trial B-13R.

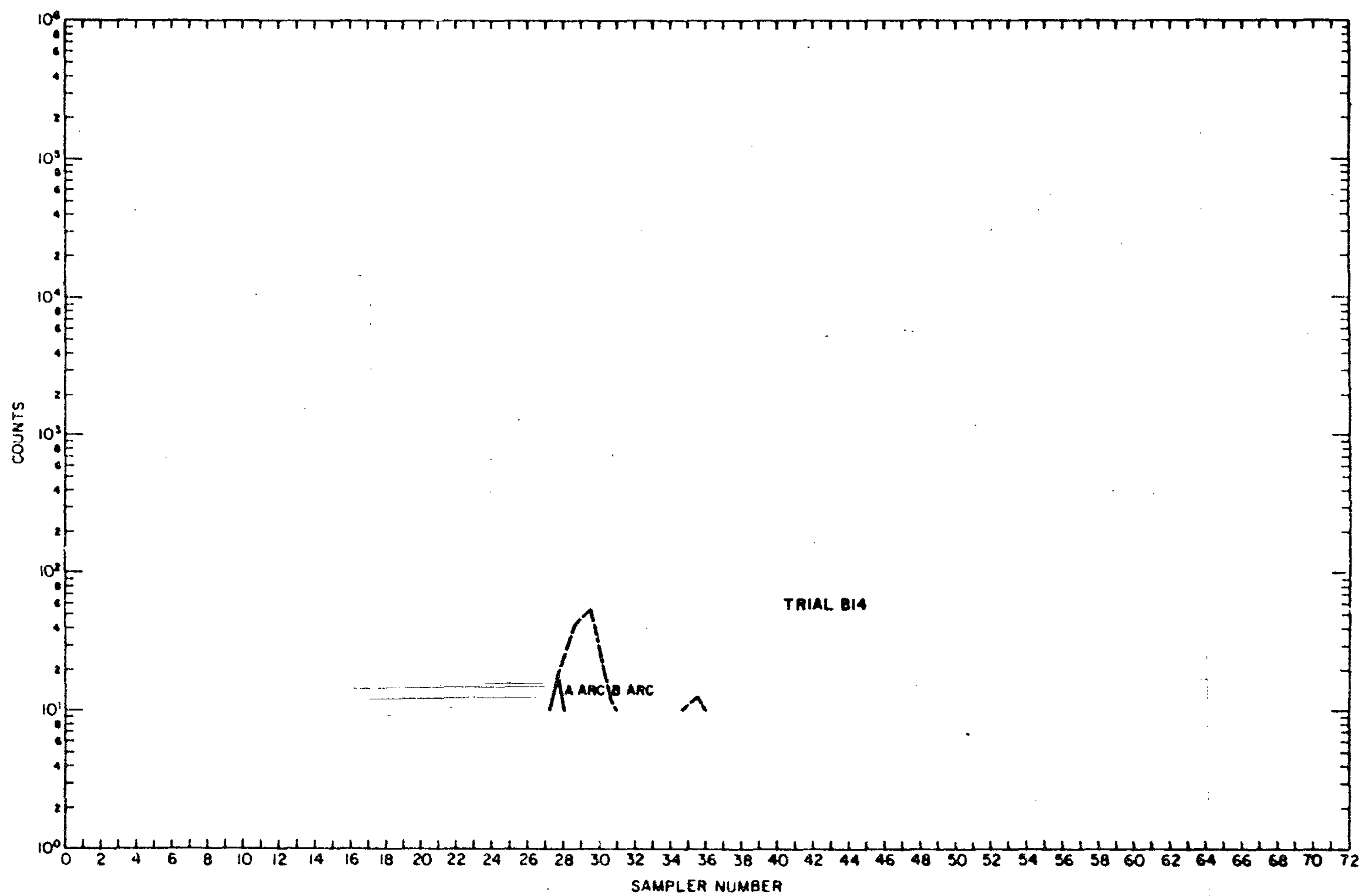


Figure III-29. Smoothed Crosswind Count Profile for Trial B-14.

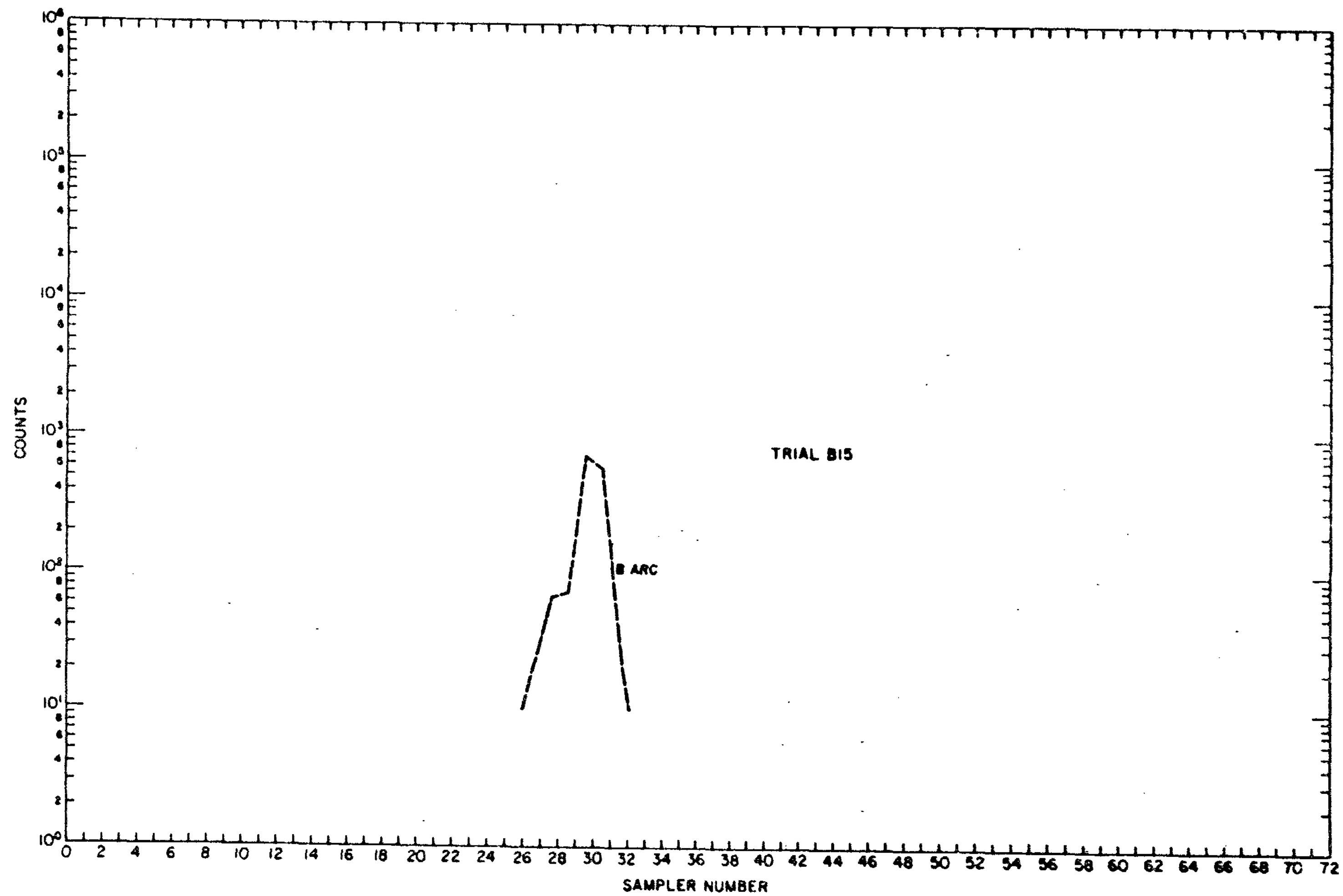


Figure III-30. Smoothed Crosswind Count Profile for Trial B-15.

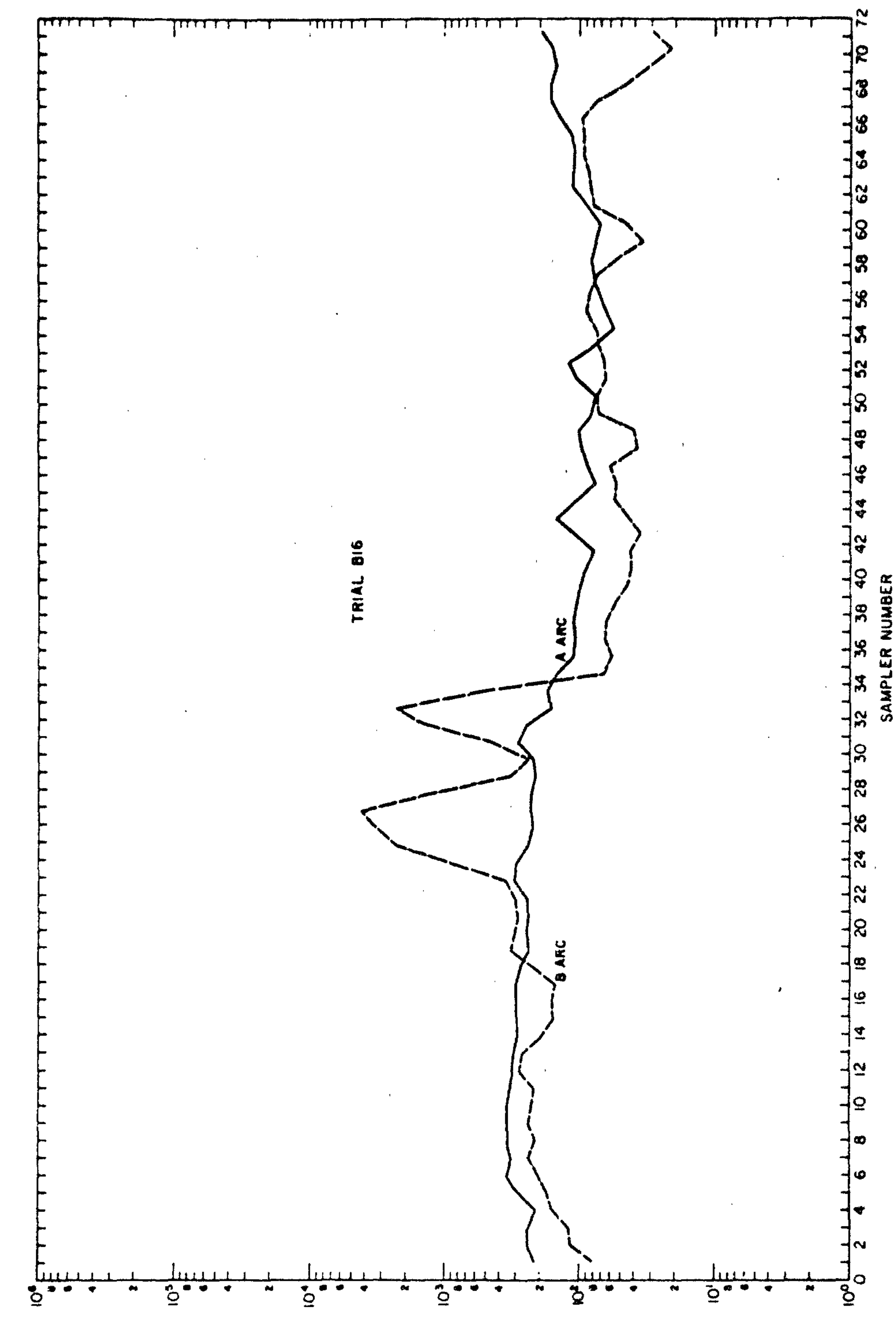


Figure III-31. Smoothed Crosswind Count Profile for Trial B-16.

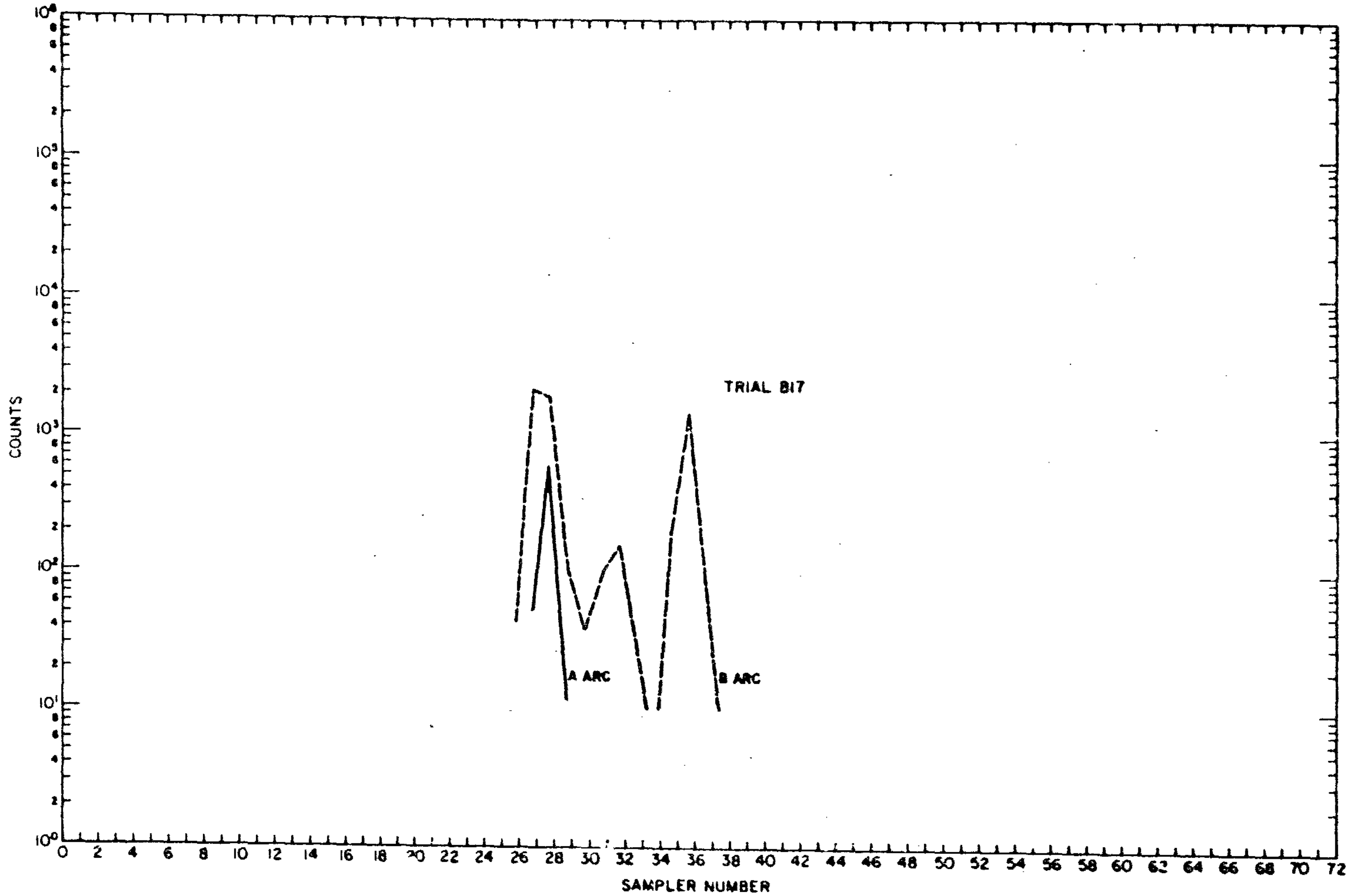


Figure III-32. Smoothed Crosswind Count Profile for Trial B-17.

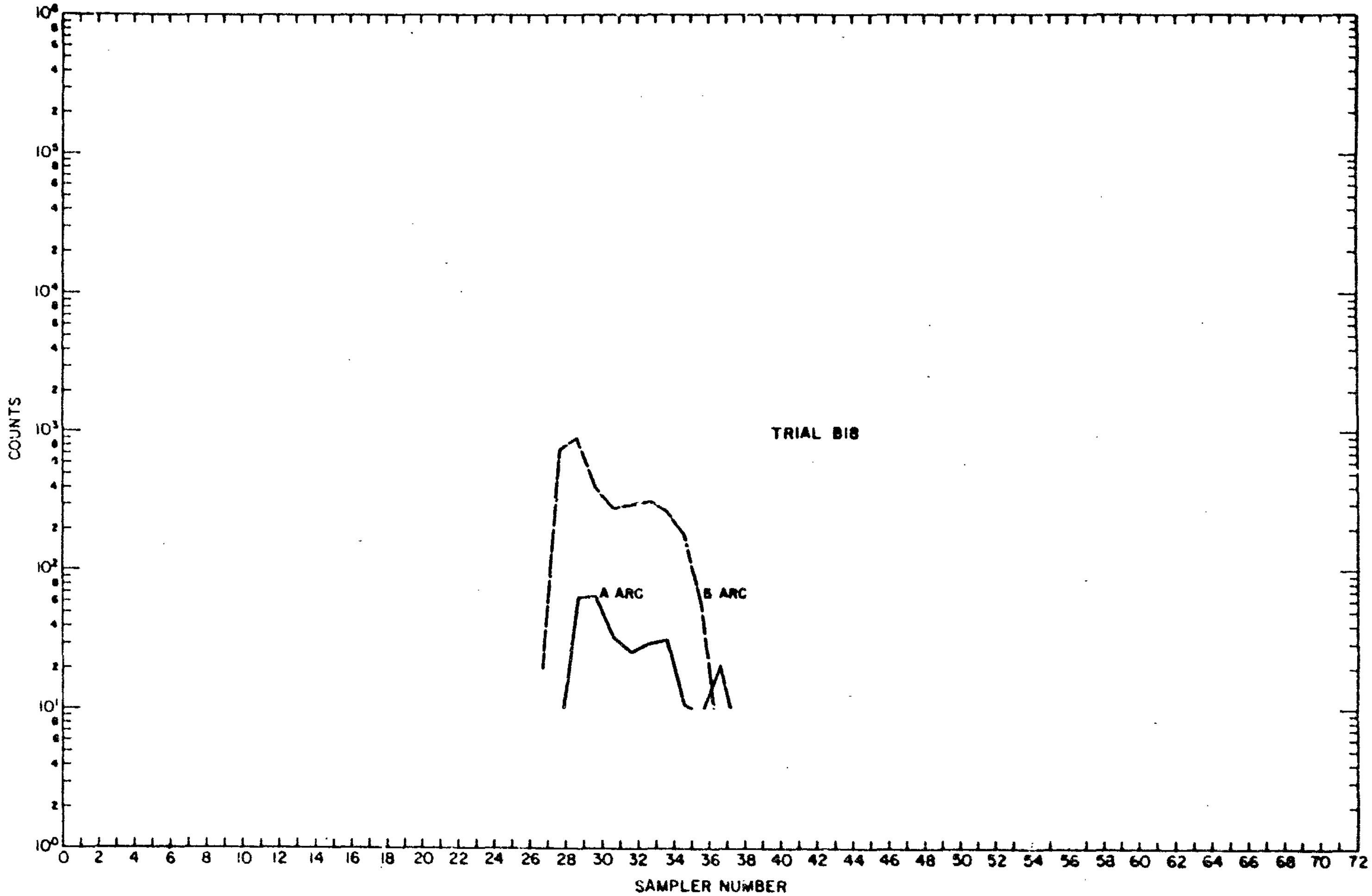


Figure III-33. Smoothed Crosswind Count Profile for Trial B-18.

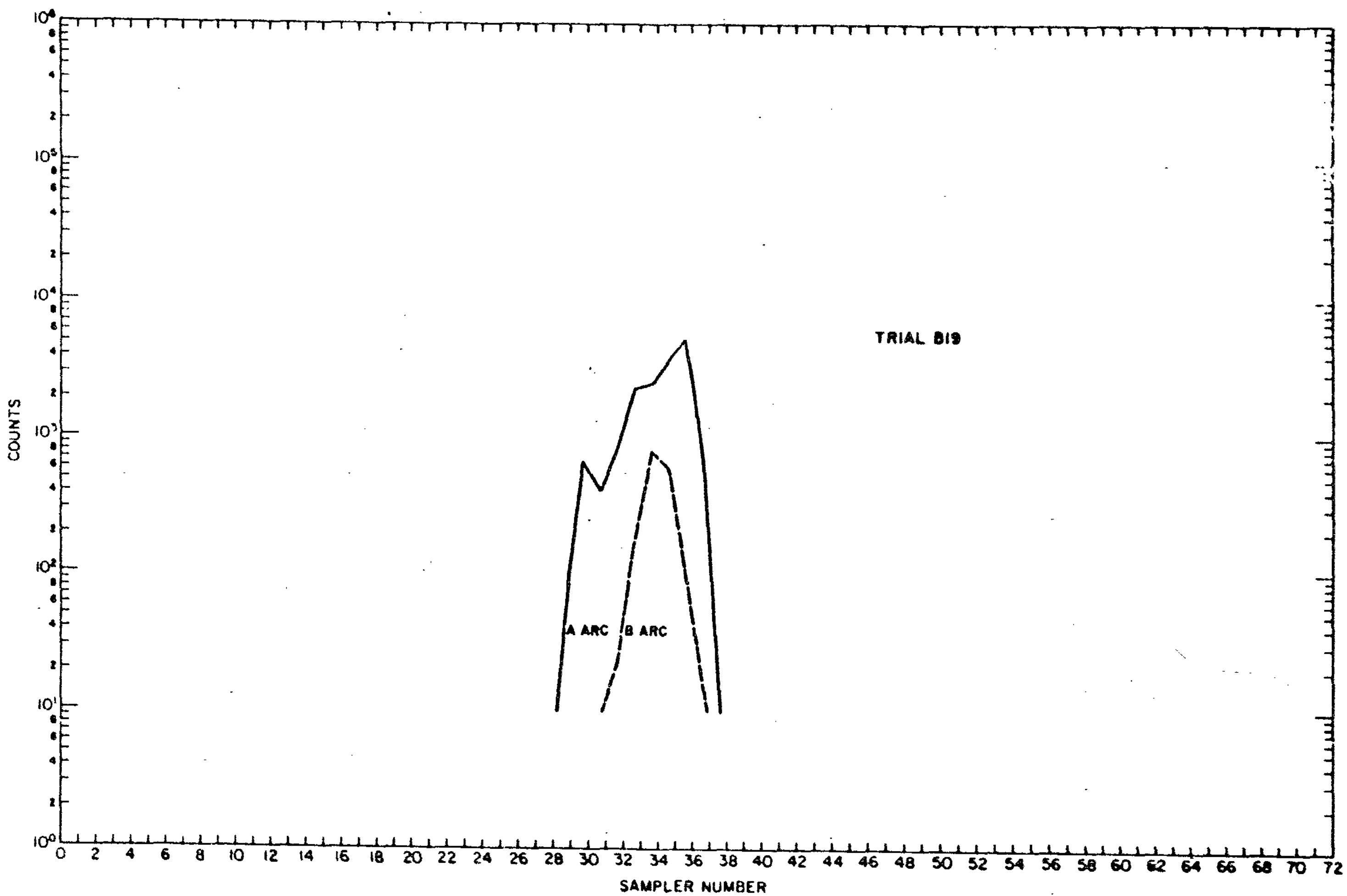


Figure III-34. Smoothed Crosswind Count Profile for Trial B-19.

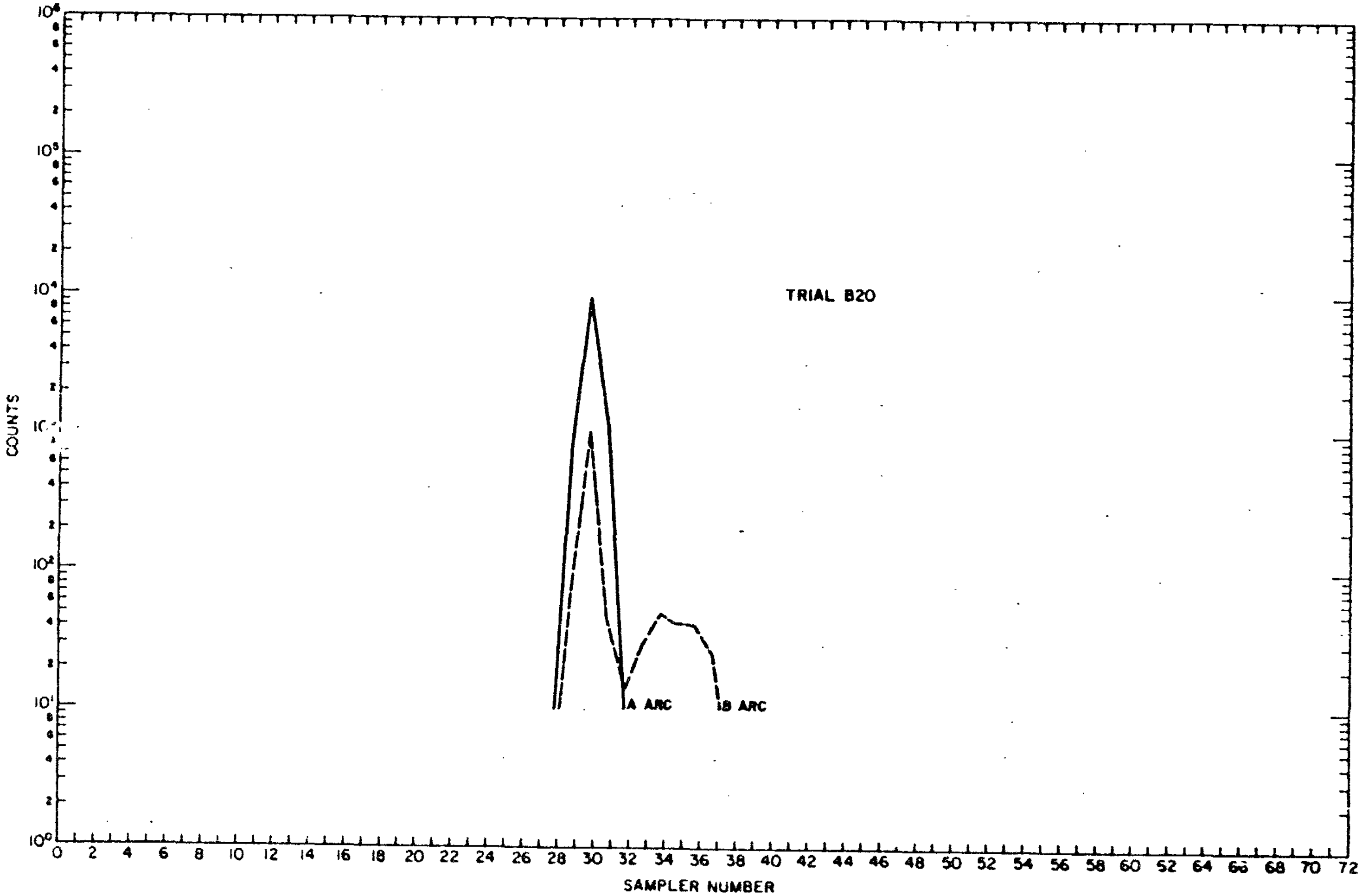


Figure III-35. Smoothed Crosswind Count Profile for Trial B-20.

APPENDIX IV. ISOPLETH ANALYSIS

Isopleth analyses of adjusted rotorod particle counts graphically express some of the diffusion conditions experienced in a field test. The rod count was adjusted for sampling efficiency of FP used in each trial. Since the density of sampling was not sufficient for a very reliable analysis, it was necessary, in some cases, to resort to interpretation in developing the isopleth patterns. For this reason, only a few examples have been included. The examples provide validation for some of the conclusions derived.

Trial B-20 is representative of a high wind-speed nighttime situation with very little evidence of lateral dilution (Figure IV-1). This trial is a good example of a narrow plume which can conceivably travel undetected between two sampling stations. It is evident from this example, that in order to detect peak concentrations at any given point, a much more dense sampling network would be required at the periphery of TEAD-S.

Trial B-15 is a typical example of a cloud remaining aloft in moderate wind-speed nighttime conditions (Figure IV-2). Trial A-10 is an example of moderate wind speed conditions with a minimum of lateral dilution capabilities evident (Figure IV-3), representing a well-behaved dilution pattern for daytime conditions. Trial B-9 provides an example of a narrow dilution pattern for a light wind-speed nighttime situation (Figure IV-4). It is evident that a more dense network of samplers would be required at the periphery for this type of dilution situation.

Trials A-3, B-3, and B-12R depict daytime and nighttime meandering situations (Figures IV-5, IV-6, and IV-7). These conditions also represent potential pooling situations and provide evidence that pooling can occur on the installation. Trial B-3 especially represents an early morning pooling situation in which no positive sampling was experienced at any of the peripheral stations.

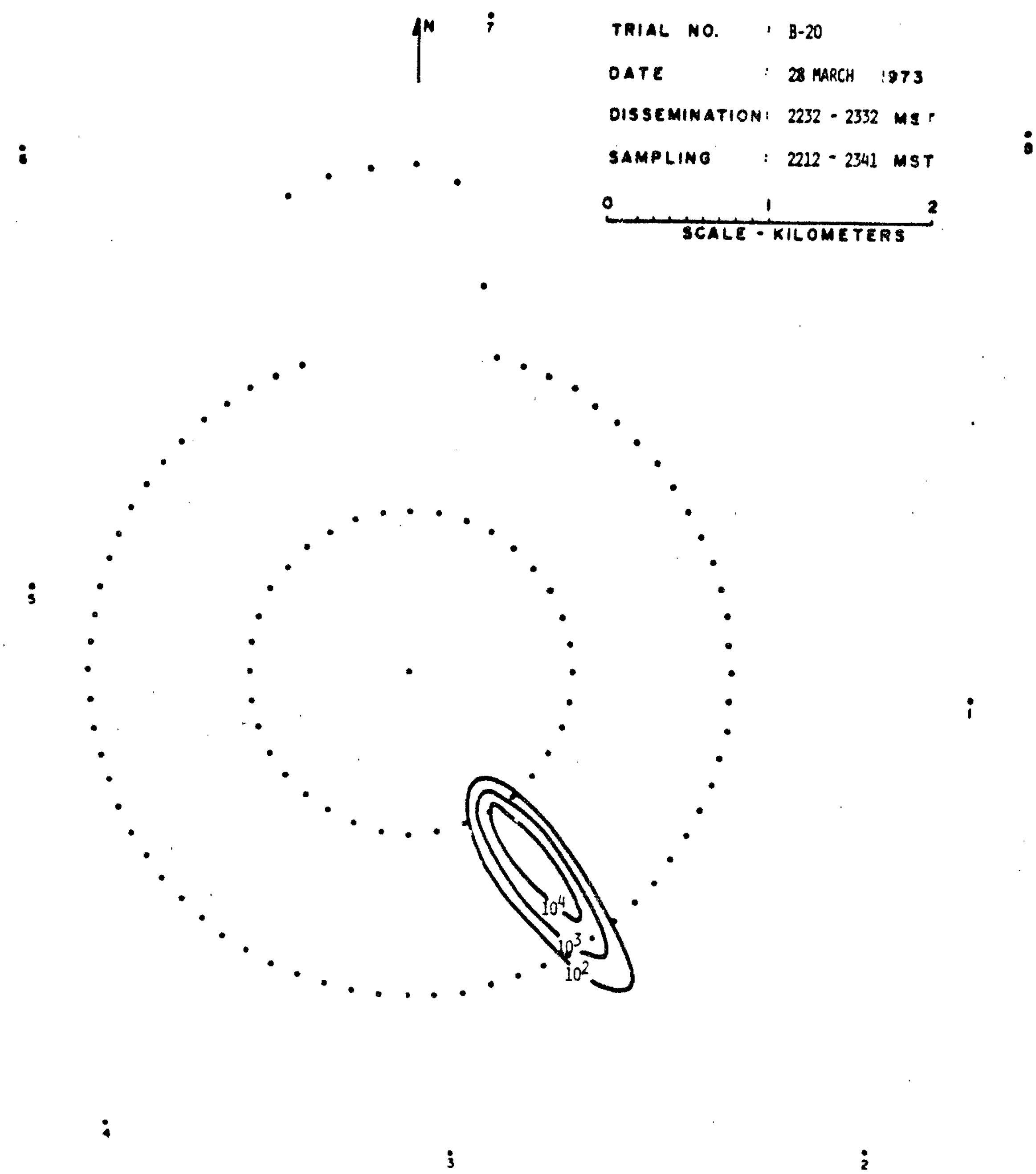


FIGURE IV-1. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL B-20.

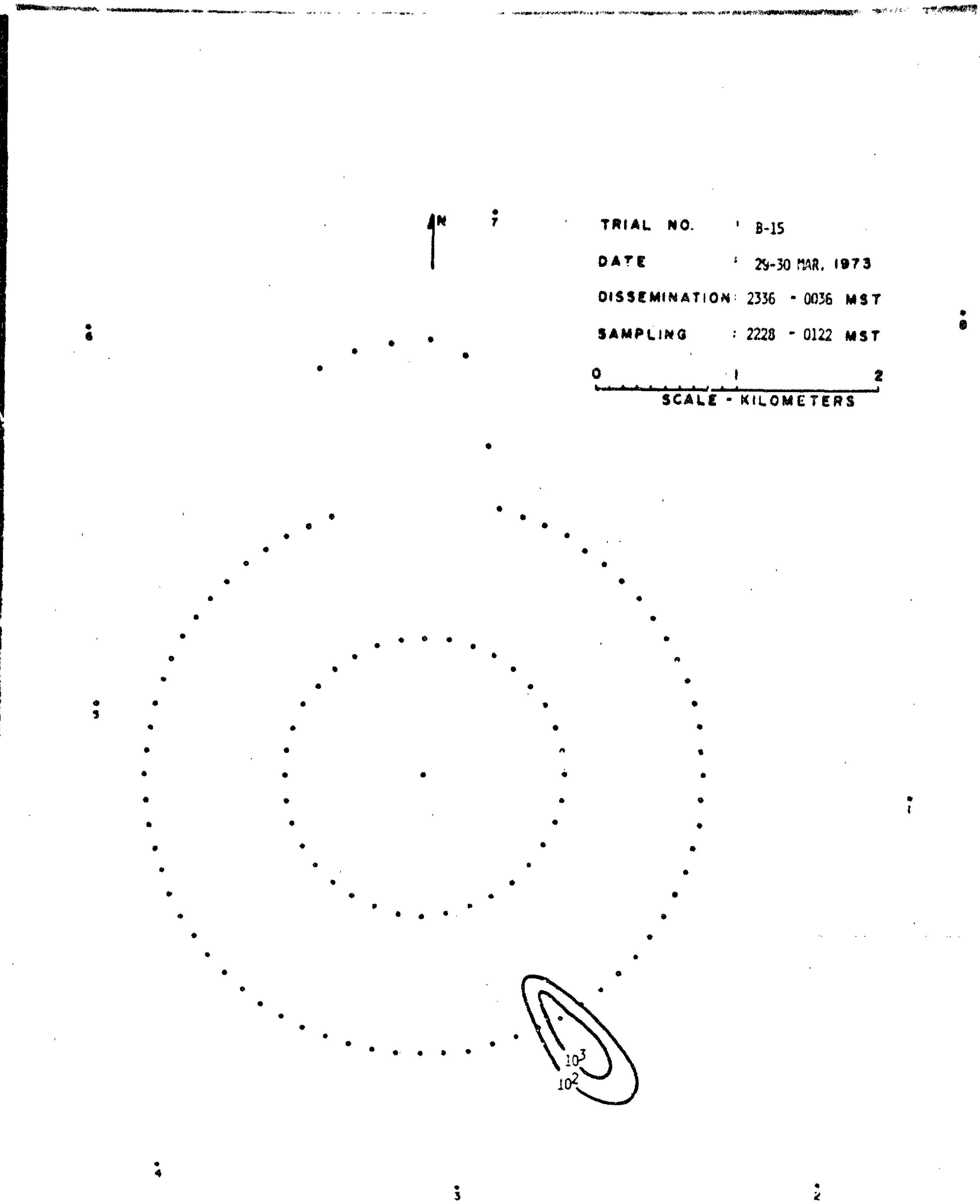


FIGURE IV-2. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL B-15.

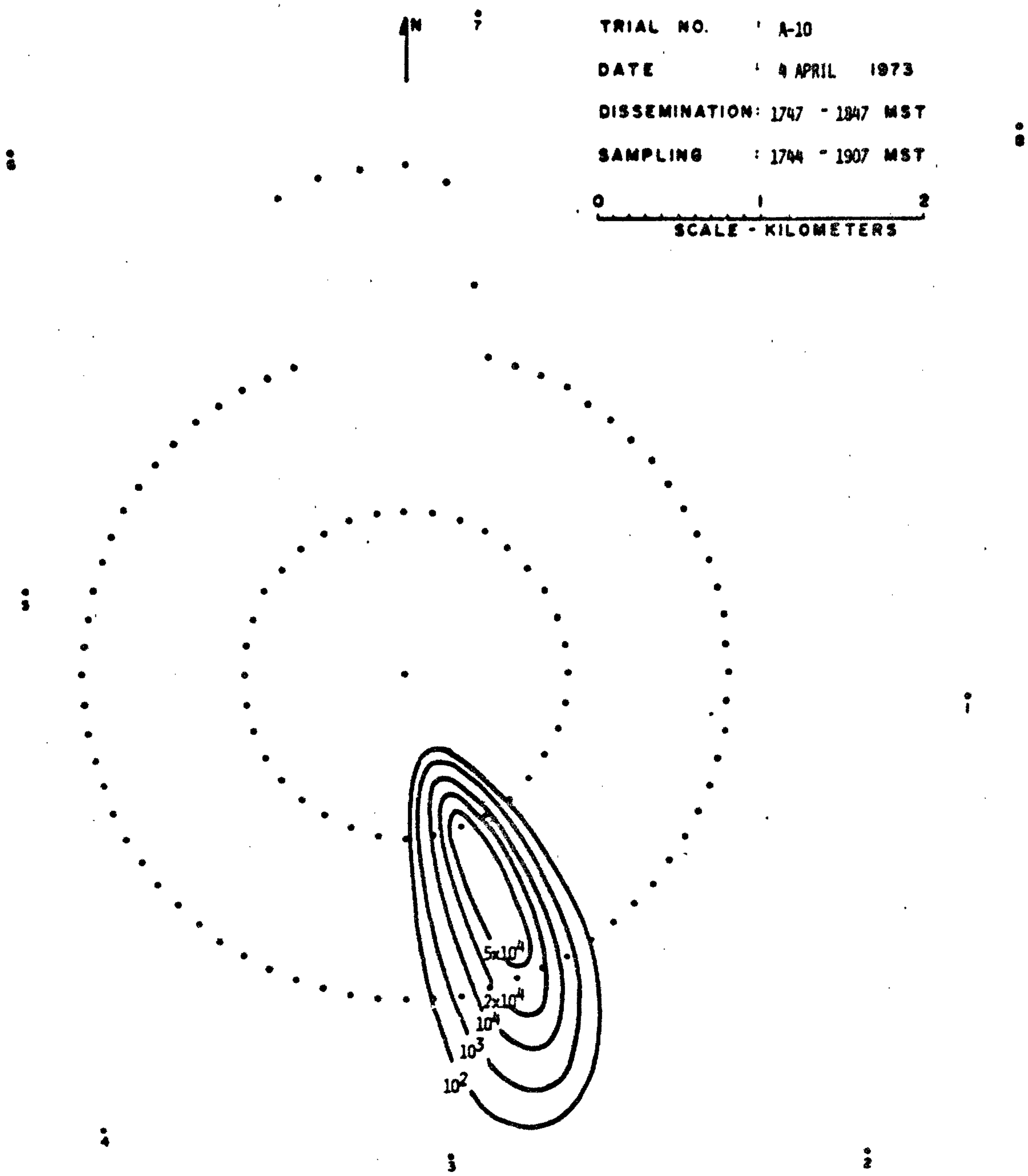


FIGURE IV-3. ISOPLETHS OF ADJUSTED ROD COUNTS(PARTICLES) - TRIAL A-10.

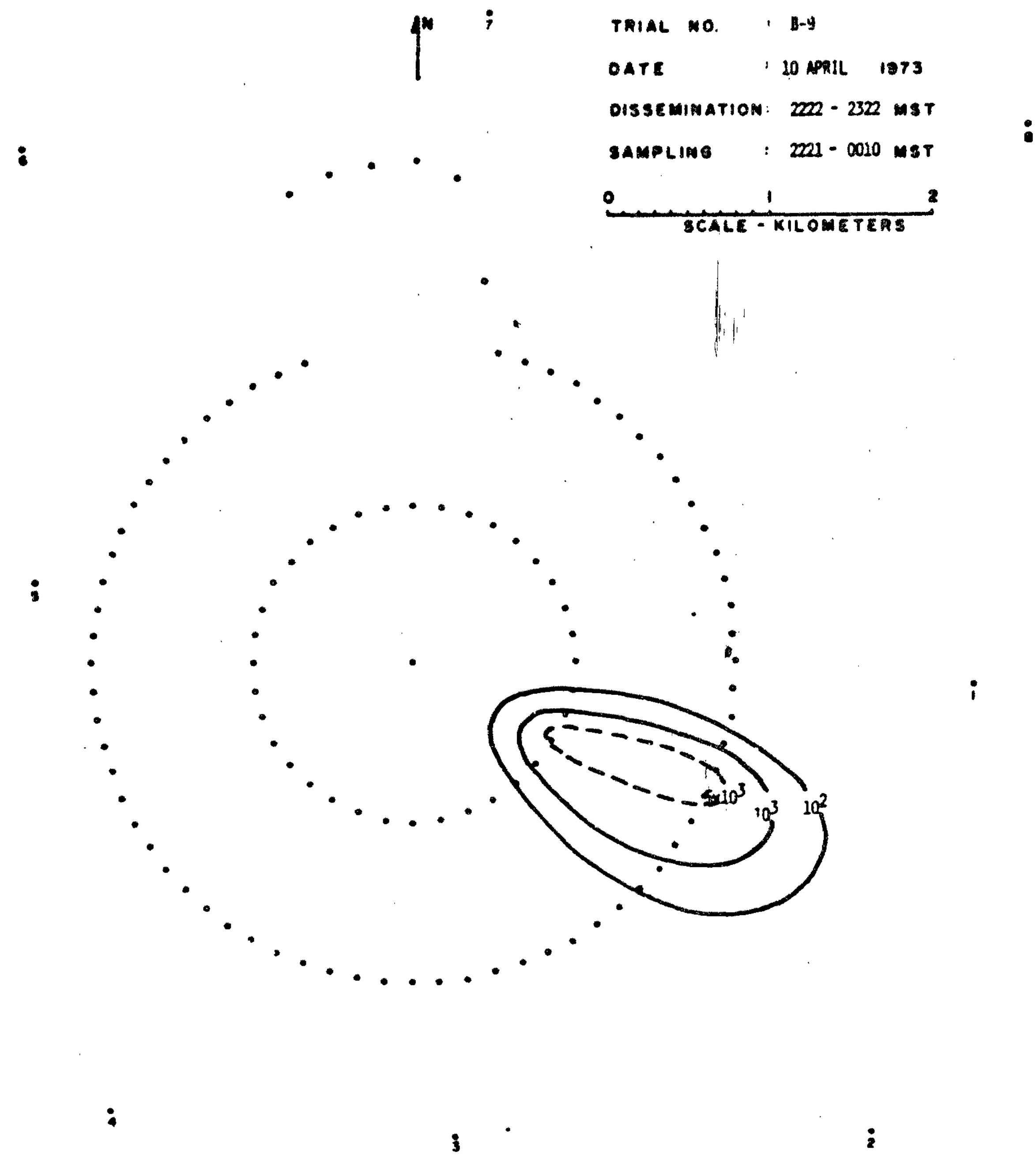


FIGURE IV-4. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL B-9.

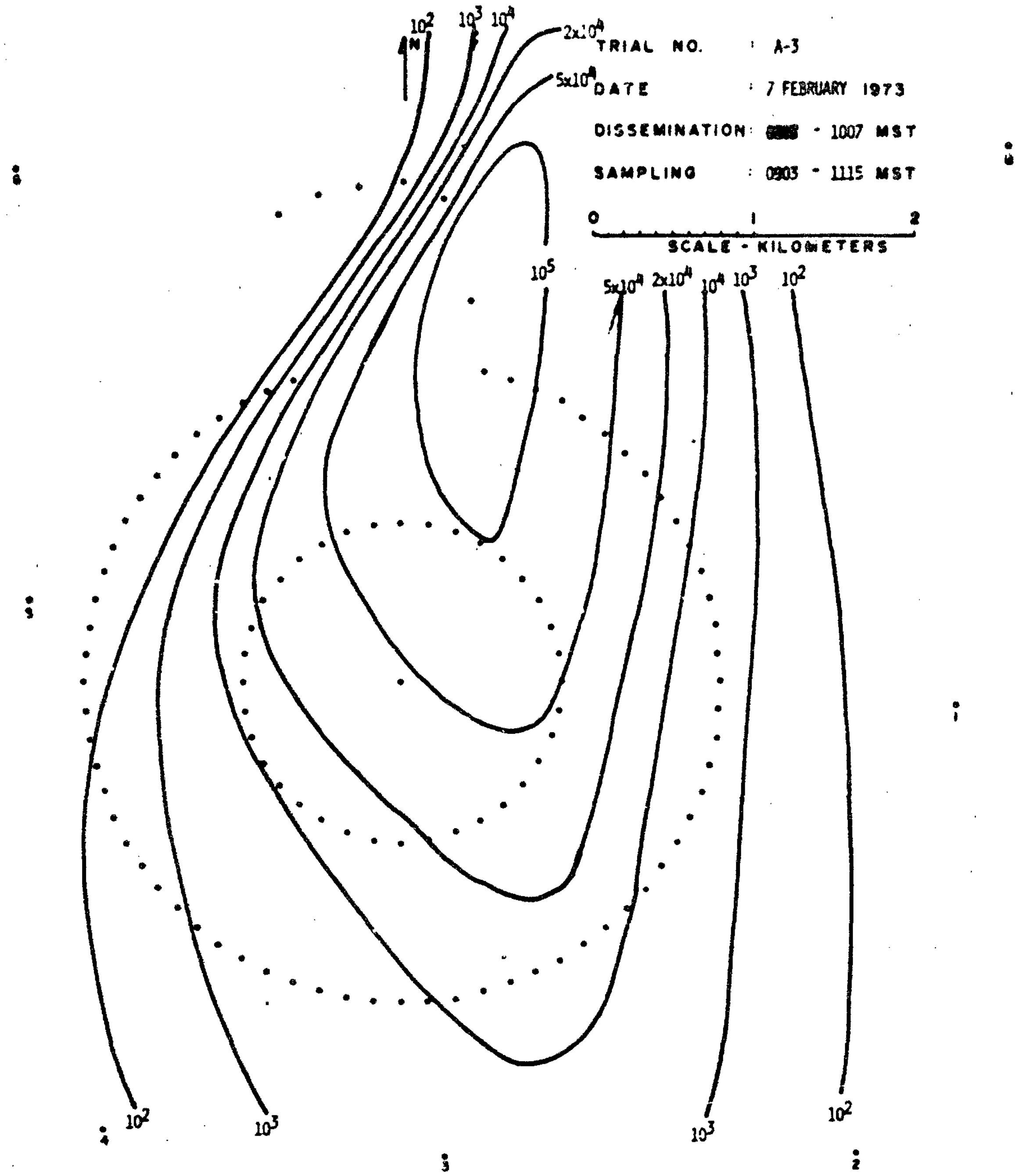


FIGURE IV-5. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL A-3.

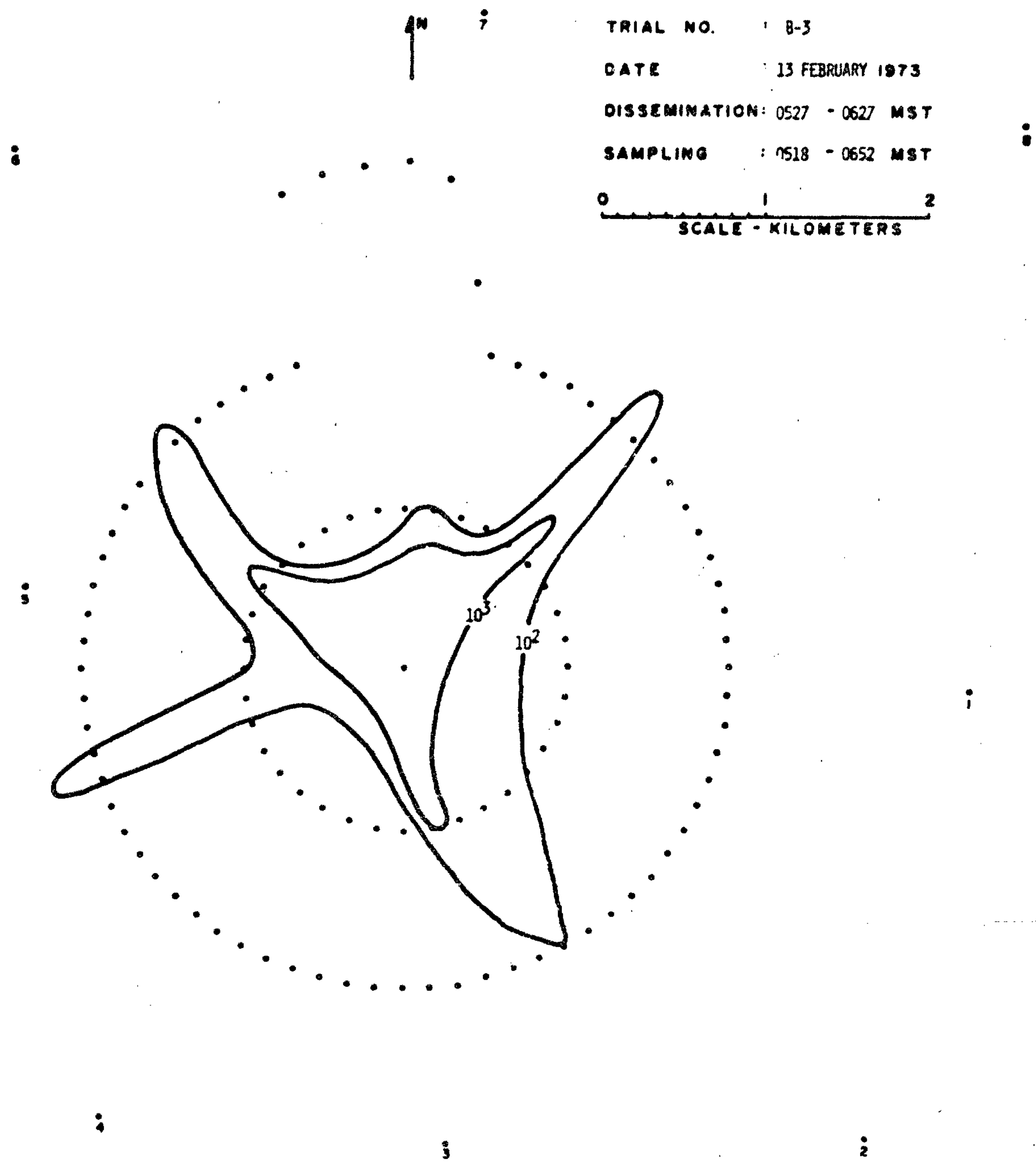


FIGURE IV-6. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL B-3.

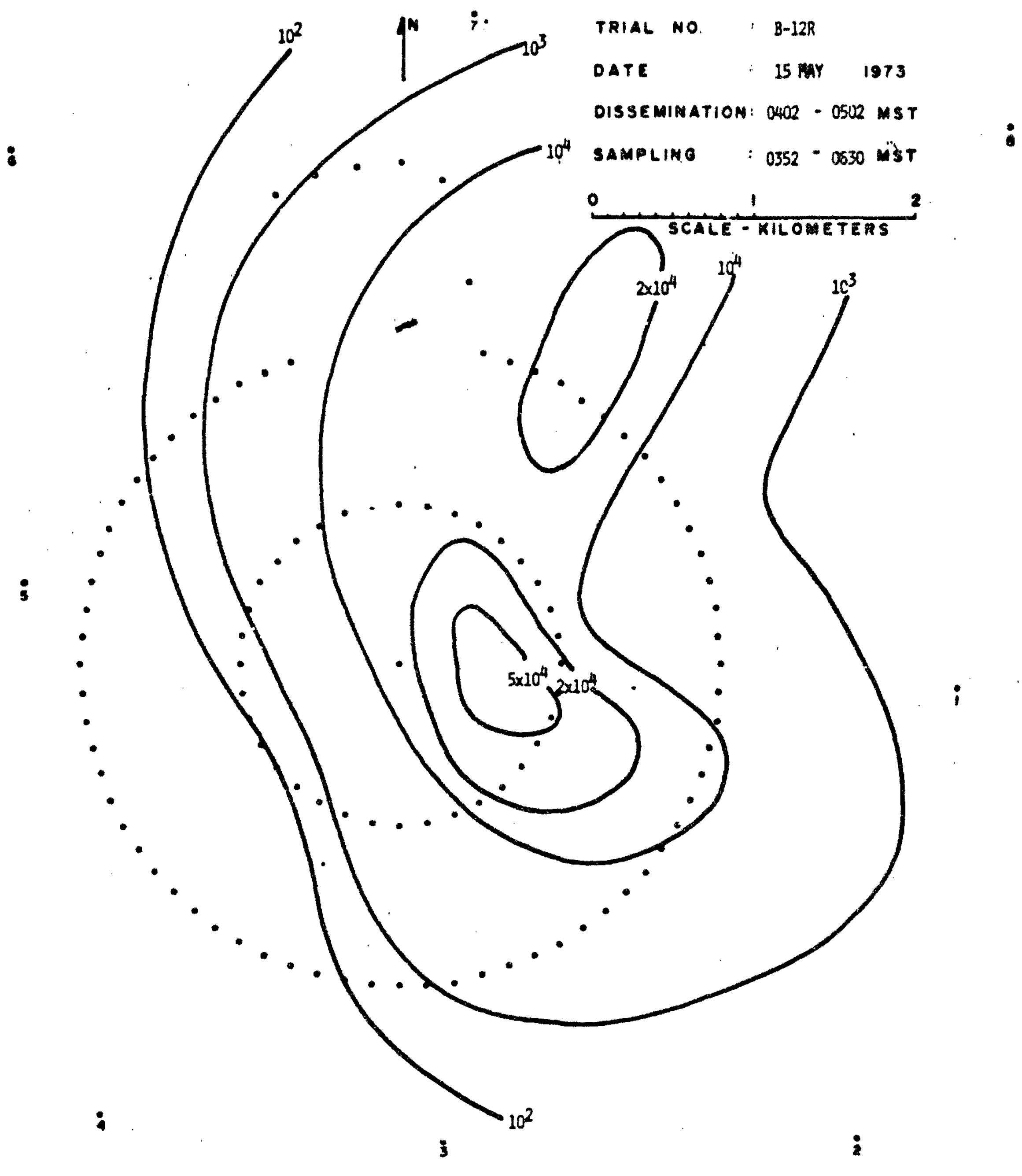


FIGURE IV-7. ISOPLETHS OF ADJUSTED ROD COUNTS (PARTICLES) - TRIAL B-12R.